DOCUMENT RESUME

ED 325 677 CE 056 258

AUTHOR Slack, Don
TITLE Testing and Troubleshooting. Electronics Module 7. Instructor's Guide.
INSTITUTION Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE 90
NOTE 91p.; For related documents, see ED 315 659-662 and CE 056 256-261.
AVAILABLE FROM Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (Order No. 70-5007-I: $7.05).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Behavioral Objectives; Competency Based Education; *Electronics; *Equipment Maintenance; Evaluation; *Industrial Arts; Learning Activities; Learning Modules; Postsecondary Education; Problem Solving; *Repair; Secondary Education; State Curriculum Guides; *Trade and Industrial Education; *Troubleshooting
IDENTIFIERS Missouri

ABSTRACT

This module is the seventh of 10 modules in the competency-based electronics series. Introductory materials include a listing of competencies addressed in the module, and a cross-reference table of instructional materials. Three instructional units cover: block diagrams; board-level repairs; and component-level troubleshooting. Each unit includes some or all of the following components: performance objectives; information sheets; transparency masters; handouts; assignment sheets; job sheets; and unit test with answer key. Special instructions are included in the notes to the instructor section near the beginning of each unit. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

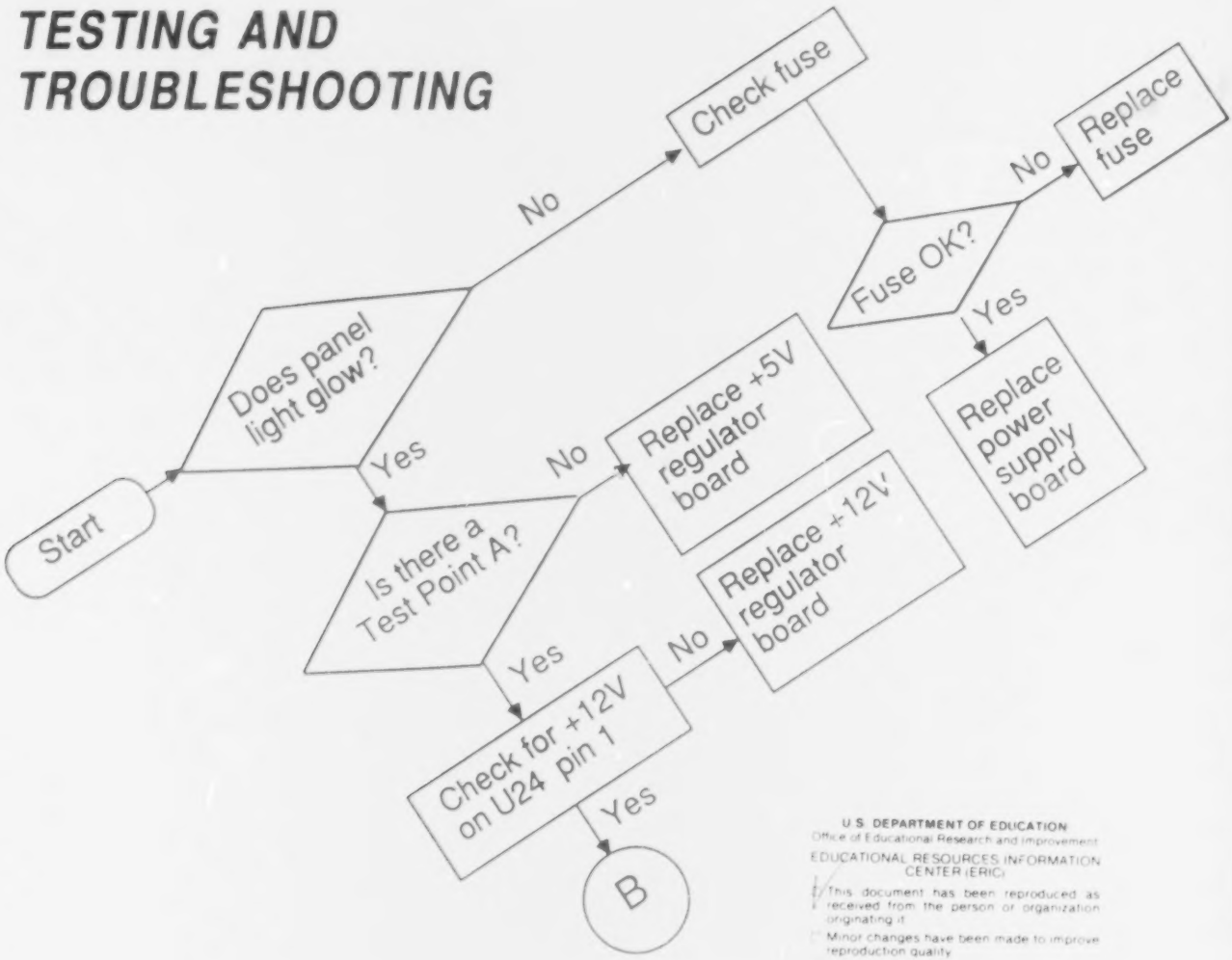
ED 256727

ELECTRONICS

Module

7

TESTING AND TROUBLESHOOTING



U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

Minor changes have been made to improve reproduction quality.

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)"

CE 036 258

Modules in this IML Electronics series

1: *Electronic Safety* by Bill Tharp
2: *Fundamentals of Electronics* by Jim Everett
3: *Digital Logic Application* by Ed Carter and Mark Murphy
4: *Circuit Construction Techniques* by Don Slack
5: *Semiconductor Devices and Applications* by John Chappell, Bill Franken and Mark Murphy
6: *Receivers and Transmitters* by Jim Everett
7: *Testing and Troubleshooting* by Don Slack
8: *Microprocessor and Computer Systems* by Don Slack
9: *Optical Electronics* by Bill Franken
10: *Electromechanical Devices and Controllers* by Ed Carter

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

ELECTRONICS

Module 7: Testing and Troubleshooting

by

Don Slack

Diane M. Davis, editor/project coordinator
Instructional Materials Laboratory
8 London Hall
University of Missouri-Columbia
Columbia, MO 65211

1990

Instructor's Guide
Catalog No. 70-5007-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This electronics guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future electronics curriculum modifications will begin with this guide. The electronics field is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
Industrial Education
Department of Elementary and Secondary Education

Charles "Chuck" Waibel, director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGMENTS

This electronics guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the electronics competency profile developed by industry and education professionals in the state.

When searching for current electronics materials to adopt or utilize in the guide's development, comparable materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which Missouri is a member. MAVCC materials, therefore, have been relied upon as a resource for this guide. A debt of thanks is owed to the entire MAVCC organization for the research and development of these electronics materials.

Special appreciation is given to the writers (Ed Carter, John Chappell, Jim Everett, Bill Franken, Mark Murphy, Don Slack and Bill Tharp) for their self-motivation, reliability and technical expertise. IML employees Crystal Dietiker and Donna Curtis contributed greatly to the guide's production.

These industry representatives and educators contributed to the guide as members of the advisory committee.

Ed Carter, Columbia Area Career Center, Columbia
John Chappell, State Fair Community College, Sedalia
Jim Everett, Platte Co. Area Vocational-Technical School (AVTS), Platte City
Bill Franken, Maple Woods Community College, Kansas City
Linda Miller, St. Louis Community College at Florissant Valley
Mark Murphy, Davis H. Hart Mexico AVTS, Mexico
Don Slack, Graff Area Vocational Center, Springfield
Bill Tharp, Chillicothe AVTS
Charles Waibel and Judith Moore, Division of Vocational & Adult Education, Department of Elementary and Secondary Education, Jefferson City

Educators who field-tested the guide in the classroom include the following.

Don Campbell, Boonslick AVTS, Boonville
John Chappell, State Fair Community College, Sedalia
Bob Chenoweth, Chillicothe AVTS
Jim Everett, Platte Co. AVTS, Platte City
Don Kennison, Nichols Career Center, Jefferson City
Don Mallory, Cass County AVTS, Harrisonville
Linda Miller, St. Louis Community College at Florissant Valley
Don Slack, Graff Area Vocational Center, Springfield
Lawrence Vance, Rolla AVTS
Mark Ward, Lewis & Clark Technical School, St. Charles

Support and contributions of IML staff members were instrumental to this module's development.

Harley Schlichting, director
Amon Herd, associate director
Phyllis Miller and Dan Stapleton, assistant directors
Sharon Dyer, graphic designer
Hsiu-Nien (Shelley) Chen, student assistant - technical
Donna Curtis and Lori Holliday, word processors
Mary Beth Ramsey, student assistant - clerical

TABLE OF CONTENTS

Unit I: Block diagrams 1

Unit II: Board-level repairs 49

Unit III: Component-level troubleshooting 81

COMPETENCIES ADDRESSED IN THIS MODULE

H. **Test Equipment**

1. Describe the operation and demonstrate the use of an oscilloscope
2. Describe the operation and demonstrate the use of multimeters; i.e., VOM, EVM or DVM
3. Describe the operation and demonstrate the use of signal generators; i.e., audio, RF or function
4. Describe the operation and demonstate the use of a frequency counter
5. Describe the function and application of analyzers; i.e., Signature, Data, LOGS, Spectrum or Components
6. Describe the operation and demonstrate the use of logic probes
7. Describe the operation and demonstrate the use of digital breakout boxes
8. Describe the operation and demonstrate the use of analog breakout boxes

N. **Logical Steps of Troubleshooting**

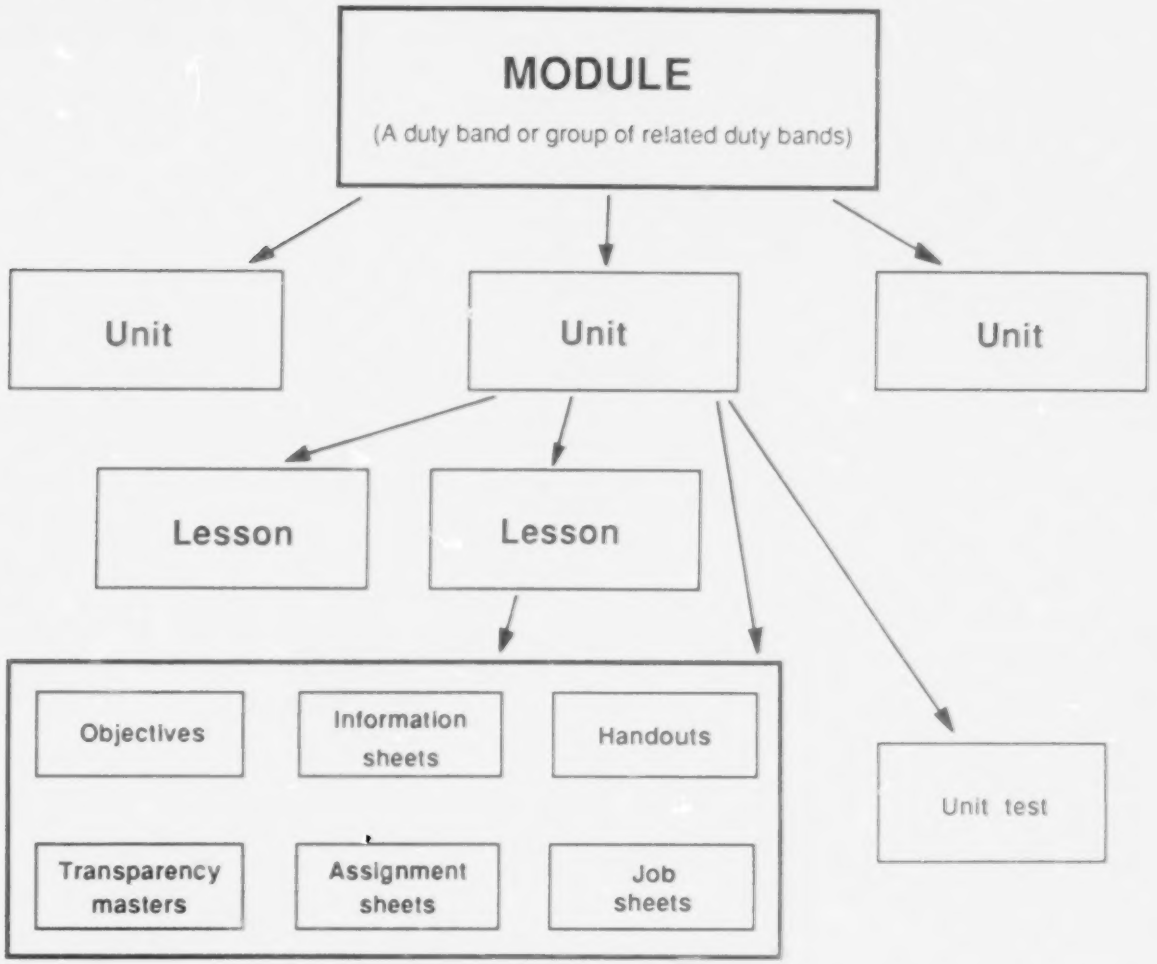
1. Describe system operation using block diagram
2. Identify problem area by symptom
3. Diagnose by signal tracing and/or injecting
4. Isolate defective unit, circuit and components
5. Test for proper operation after repair

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Electronics guide contains ten modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- 3 = **Mastery** - can work independently with no supervision
- 2 = **Requires supervision** - can perform job completely with limited supervision
- 1 = **Not mastered** - requires instruction and close supervision
- N = **No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1; the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage, while **WARNING** statements recommend procedures to avoid bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might

be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Electronics guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all ten modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 7: TESTING AND TROUBLESHOOTING

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Compe-tency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
H1-3	III 1.1-1.5, 2.1-2.2		III 1.1-1.3		III 1.1, 2.1		
H4	XIII 1.4b, c				XIII 1.2, 1.3		Semiconductor module
H5	II 3.1, 3.2, III 2.1		II 3.1	II 3.1		II 14, 15	Receivers & Trans-mitters module
H6	VII 1.1, 1.2, 2.1-2.3				VII 1.1, 2.1, VIII 1.1		Digital module
H7-8	V 1.1, VI 2.11				V 1.1, 1.2, VI 2.1	V 18, VI 8	Microprocessors module
N1	I 1.1-3.2		I 1.1, 2.1, 3.1	I 1.1, 2.1, 3.1		I 1-19	
N2	II 1.1-1.6, 2.5		II 1.1		II 1.1, 2.1	II 1-3, 5-8	
N2-5	III 1.1-1.5, 2.1-2.2		III 1.1-1.3		III 1.1, 2.1		
N5	II 2.1-2.5			II 2.1	II 2.1	II 4	

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe system operation using a block diagram. This knowledge will be evaluated by achieving the specified score on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Define terms and definitions related to block diagrams.

1.2 Describe aspects of a power supply's schematic diagram.

1.3 Describe aspects of a simple block diagram.

1.4 Describe components of a detailed block diagram.

2.1 Compare aspects of the block diagram with the schematic diagram.

2.2 Trace signal flow through a functional block diagram.

3.1 Determine operation of a system from comparison with its block diagram.

3.2 Draw system block diagram by observing schematic diagram. (competency N1)

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: POWER SUPPLY BLOCK AND SCHEMATIC DIAGRAMS

   a. Information outline

   b. Handout

      HO 1.1: Power supply

   c. Assignment sheet

      AS 1.1: Power supply block diagrams

   d. Answers to assignment sheet

2. Lesson 2: AUDIO AMPLIFIER BLOCK AND SCHEMATIC DIAGRAMS

   a. Information outline

   b. Handout

      HO 2.1: Audio amplifier

   c. Assignment sheet

      AS 2.1: Audio amplifier block diagrams

   d. Answers to assignment sheet

3. Lesson 3: RECEIVER BLOCK AND SCHEMATIC DIAGRAMS

   a. Information outline

   b. Handout

      HO 3.1: AM radio receiver

   c. Assignment sheet

      AS 3.1: Receiver block diagrams

   d. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Brenner, Robert C. IBM PC Advanced Troubleshooting and Repair. Indianapolis, IN: Howard W. Sams & Co. Inc., 1988.

2. Cook, Nigel P. Introductory DC/AC Electronics. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

3. Frenzel, Louis E. Communication Electronics. St. Louis: McGraw-Hill, 1989.

4. Grob, Bernard. Basic Electronics. 6th ed. New York: McGraw-Hill, 1989.

5. Mager, Robert F. Troubleshooting the Troubleshooting Course or Debug d'Bugs. Belmont, CA: David S. Lake Publishers, 1982.

6. Paynter, Robert T. Introductory Electronic Devices and Circuits. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

7. Schuler, Charles A. Electronics: Principles and Applications. 3rd ed. New York: McGraw-Hill, 1989.

8. Tokheim, Roger L. Digital Electronics. 3rd ed. New York: McGraw-Hill, 1989.

9. PhotoFacts Index. Indianapolis, IN: Howard W. Sams & Co., Inc., 1990.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid America Vocational Curriculum Consortium, 1987.

2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid America Vocational Curriculum Consortium, 1980.

3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Compare schematic diagrams to block diagrams.

2. Discuss the use of block diagrams, such as signal or data flow between blocks and interaction of blocks within the diagram.

3. Explain the use of troubleshooting schematics.

   a. Factory service manuals

b. Commercial schematic services available

B. Suggested student activities

1. Trace signal and data flow through block diagrams.

2. Use schematic diagrams of simple power supply, audio amplifier and receiver systems to draw a functional block diagram.

C. Suggested supplemental materials

1. PhotoFacts Index. Indianapolis, IN: Howard W. Sams & Co., Inc., 1990. (Includes "ComputerFacts" listing for various computers, printers, disk drives and CRT displays. Available from electronics wholesale outlets)

2. Amplifier Troubleshooting (video, E-87-333). Sedalia, MO: The Media Center, State Fair Community College, 1987. (Available for purchase from SFCC; available for loan from Missouri Vocational Resource Center, phone 800/392-7217 or 314/882-9610)

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

LESSON 1: POWER SUPPLY BLOCK AND SCHEMATIC DIAGRAMS

NOTE: After this lesson, the student should be able to follow signal flow through the system and explain the interaction of sections of the system.

I. Terms and definitions

A. Schematic diagram--detailed diagram of electronic circuit symbols showing actual component parts and connections

B. Block diagram--diagram using block or box to indicate stage or section arrangement of an electronic system

C. Signal flow--arrows on the block diagram showing direction of signal movement into and out of blocks

D. Section--major subdivision of complete electronics device; can be a stage or easily identifiable component

E. Stage--semiconductor device and all component parts that make up an amplifier

F. Transducer--device that converts energy from one form to another

G. System--complete electronic unit consisting of all component parts and stages for a working unit

II. Power supply schematic diagram **(HO 1.1A)**

A. The circuit is shown in component detail form.

1. Schematic symbols for all component parts

2. Shows interconnection of each part

B. Input

1. The exact circuit is shown.

2. AC cord connections are shown on the power supply.

3. Current path can be traced through the input circuit.

C. Output

1. The exact circuit is shown.

2. Filter output is shown on the power supply.

3. DC voltage sources are indicated on the schematic.

4. Current path can be traced through the output circuit.

D. Circuits between input and output

1. Schematic symbols of each component part
2. Circuit arrangement of each component part to show how the circuit works

E. Direction of signal flow

1. By convention, the signal moves from left to right.
2. Schematic diagrams are drawn to show signal flow from left to right.

F. Analysis of power supply schematic diagram

1. AC input section
   a. Input: AC from power source
   b. Function: power cord, fuse protection, AC control switch
   c. Output: AC passed to transformer section
   d. Shows details of protection or control components and connections
2. Transformer section
   a. Input: AC from AC input section
   b. Function: step voltage up or down
   c. Output: AC passed to rectifier section
   d. Shows how many windings and connections
3. Rectifiers section
   a. Input: AC from transformer section
   b. Function: change AC to DC
   c. Output: pulsating DC passed to filter section
   d. Shows how many diodes and type of rectifier circuit
4. Filter section
   a. Input: pulsating DC from rectifier section
   b. Function: smooth, pulsating DC to pure DC
   c. Output: pure DC passed to load section
   d. Shows type of filter, components and connections
5. Load section
   a. Input: pure DC from filter section

b. Function: circuits to be powered by the power supply

c. No output in this example

d. Load(s) not shown; could be amplifier stages in a stereo or radio

III. Simple block diagram **(HO 1.1B)**

A. Same power supply

1. Functional form instead of component form

2. Function of power supply described by single block

B. Input

1. Shown as arrow pointing into block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from another place to the input of this block

C. Output

1. Shown as an arrow pointing out of block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from this block and goes to another place

D. Circuitry between input and output

1. Not shown in detail

2. Shows only function of block, not how the circuit works

3. Does not show sections of power supply within the block

E. Direction of signal flow

1. By convention, signal moves from left to right.

2. Block diagrams are drawn to show signal flow from left to right.

F. Analysis of simple block diagram

1. AC power applied to input of power supply

2. AC changed to pure DC by power supply

3. DC supplied to load(s)

IV. Detailed block diagram **(HO 1.1C)**

A. Shows same power supply

1. Functional form instead of component form

2. Shows sections within the power supply as individual blocks

B. Input

1. Shown as arrow pointing into block
2. Labeled with signal, data or voltage present
3. Indicates that voltage comes from another place to the input of this block

C. Output

1. Shown as arrow pointing out of block
2. Labeled with signal, data or voltage present
3. Indicates that voltage comes from this block and goes to another place

D. Circuitry between input and output

1. Not shown in detail
2. Shows only function of block, not how the circuit works
3. Function of each major section of the power supply shown by individual blocks

E. Direction of signal flow

1. By convention, the signal moves from left to right.
2. Block diagrams are drawn to show signal flow from left to right.

F. Analysis of power supply in detailed block diagram

1. AC input block
   a. Input: AC from power source
   b. Function: power cord, fuse protection, AC control switch
   c. Output: AC passed to transformer block
   d. Details of protection or control not shown
2. Transformer block
   a. Input: AC from AC input block
   b. Function: step voltage up or down
   c. Output: AC passed to rectifier block
   d. Does not show windings or turns ratio
3. Rectifier block
   a. Input: AC from transformer block

b. Function: change AC to DC

c. Output: pulsating DC passed to filter block

d. Does not show number of diodes or type of rectifier circuit

4. Filter block

a. Input: pulsating DC from rectifier block

b. Function: smooth, pulsating DC to pure DC

c. Output: pure DC passed to load block

d. Type of filter not shown

5. Load block

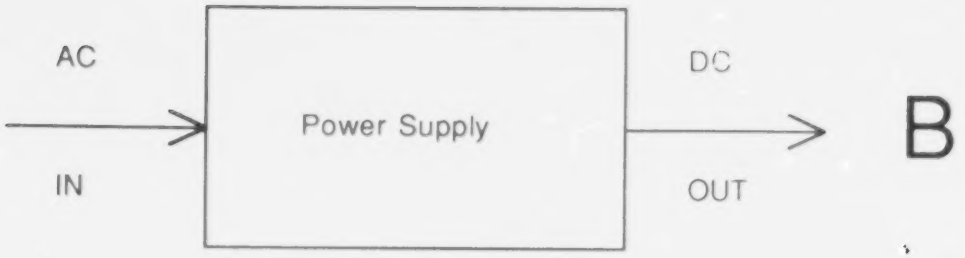
a. Input: pure DC from filter block

b. Function: circuits to be powered by the power supply

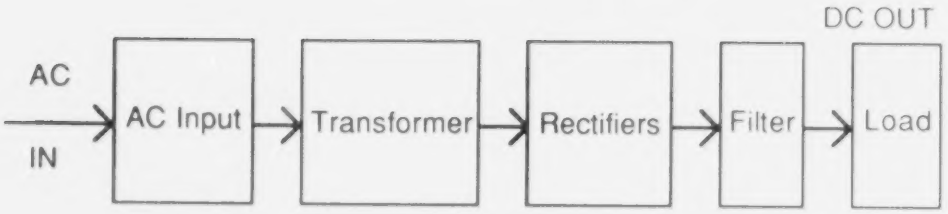
c. Output: none in this example

d. Load(s) not shown; could be amplifier stages in a stereo or radio

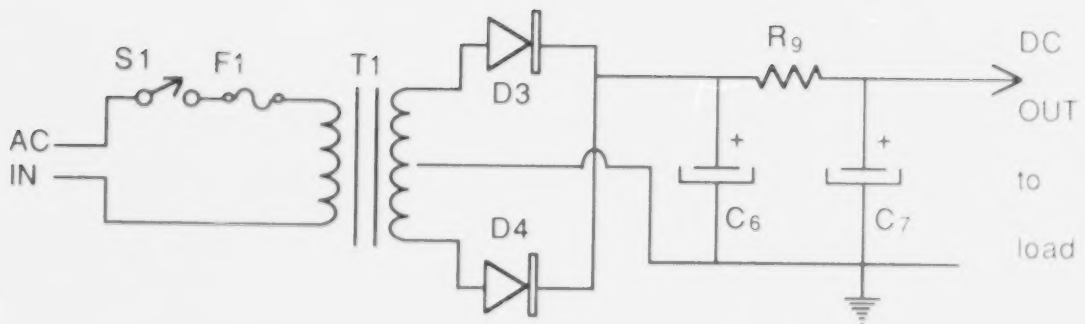
POWER SUPPLY



B



C



A

POWER SUPPLY BLOCK DIAGRAMS

1. What do the arrows represent on block diagrams?

2. Do block diagrams show what component parts make up a circuit? (Yes / no) Explain your answer.

3. Signals or information are shown moving from _____ to _____ on both schematic and block diagrams.

4. Examine the power supply block diagram in **HO 1.1**. In your own words, describe the power supply operation from the information given in the block diagram.

5. Use a pencil to sketch a box around the component parts shown on the schematic diagram. Place a box around the parts that would be included in each block on the block diagram.

   Obtain from the instructor a schematic diagram of a power supply used in your shop.

6. Draw and label a block diagram for that power supply.

7. Describe the operation of that power supply using the block diagram that you drew.

ANSWERS TO AS 1.1

1. Arrows represent the direction of signal flow.

2. No; block diagrams show what the circuit does, not what parts make up the circuit.

3. _LEFT_ _RIGHT_

4. Students should describe the following: AC coming in to the power supply, the transformer steps AC up or down, the rectifiers change AC to DC, the filters smooth the DC and pass DC on to the circuit load.

5-7. Instructor to evaluate

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

LESSON 2: AUDIO AMPLIFIER BLOCK AND SCHEMATIC DIAGRAMS

NOTE: This lesson covers the audio amplifier system operation. The student should learn to follow signal flow through the system and explain the interaction of sections of the system.

I. Amplifier schematic diagram **(HO 2.1A)**

A. Circuit shown in detail

1. Schematic symbols for all component parts
2. Interconnection of each part

B. Input

1. The exact circuit is shown.
2. Signal source connections are shown on the amplifier.
3. Current path can be traced through the input circuit.

C. Output

1. The exact circuit is shown.
2. Loudspeaker output is shown on the amplifier.
3. Current path can be traced through the output circuit.

D. Each amplifier stage between input and output

1. Schematic symbols of each component part
2. Circuit arrangement of each amplifier stage to show how each stage connects to adjacent stage

E. Circuits within each stage

1. Schematic symbols of each component part
2. Circuit arrangement of each component part to show how the stage works

F. Direction of signal flow

1. By convention, the signal moves from left to right.
2. Schematic diagrams are drawn to show signal flow from left to right.

G. Analysis of amplifier schematic diagram

1. Power supply section

   a. This section furnishes DC power for all amplifier stages.

   b. See the previous section on power supply schematic diagrams for a description.

   c. Loads for the power supply section are amplifier stages.

2. Pre-amp stage

   a. Input: audio signal from some source

   b. Function: amplifies and inverts signal

   c. Output: passes audio signal to volume control

   d. Common-emitter: NPN stage

3. Volume control section

   a. Input: audio signal from pre-amp stage

   b. Function: controls signal level to next stage

   c. Output: audio signal to driver

   d. Easy to find test point

4. Driver stage

   a. Input: audio signal from volume control

   b. Function: amplifies audio signal

   c. Output: audio current to transformer phase-splitter primary

   d. Common-emitter, PNP stage

5. Power amplifier stage

   a. Input: two signals 180° out of phase from driver stage

   b. Function: develop high signal current

   c. Output: deliver audio power to loudspeaker load

   d. Push-pull, NPN, transformer coupled

6. Loudspeaker section

   a. Input: audio signal power from power amplifier stage

   b. Function: convert audio to sound

   c. Output: sound

d. Electromechanical transducer

II. Amplifier block diagram **(HO 2.1B)**

A. Shows same amplifier

1. Functional form instead of component form

2. Each stage or section shown as a block

B. Input

1. Shown as arrow pointing into block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from another place to the input of this block

C. Output

1. Shown as arrow pointing out of block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from this block and goes to another place or block

D. Circuitry between input and output

1. Not shown in detail

2. Block shows functional stage or section

3. Shows only function of block (what the stage does, not how it works)

E. Direction of signal flow

1. By convention, signal moves from left to right.

2. Block diagrams are drawn to show signal flow from left to right.

F. Analysis of amplifier block diagram

1. Power supply section

a. This section furnishes DC power for all amplifier stages.

b. See previous section for power supply block diagram description.

c. Loads for the power supply section are amplifier stages.

2. Pre-amp block

a. Input: audio signal from some source

b. Function: amplify signal

c. Output: pass audio signal to volume control

d. Type of amplifier not shown

3. Volume control section

   a. Input: audio signal from pre-amp block

   b. Function: control signal level to next block

   c. Output: audio signal to driver block

   d. Easy to find test point

4. Driver block

   a. Input: audio signal from volume control

   b. Function: amplify audio signal

   c. Output: audio signal to power amplifier block

   d. The type of amplifier is not shown, but since the next block is shown as a push-pull amplifier, some method of phase splitting is implied.

5. Power amplifier block

   a. Input: audio signal from driver block

   b. Function: develop high signal current

   c. Output: deliver audio power to loudspeaker load

   d. Push-pull operation indicated by two blocks

   e. A single block can also be used for a power amplifier stage; push-pull operation would not be shown.

6. Loudspeaker section

   a. Input: audio signal power from power amplifier block

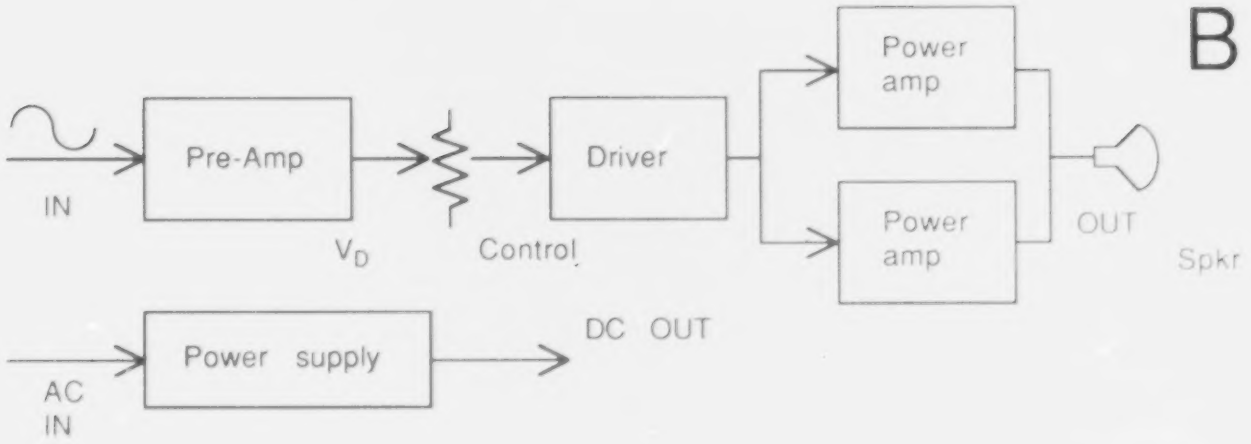
   b. Function: convert audio to sound

   c. Output: sound

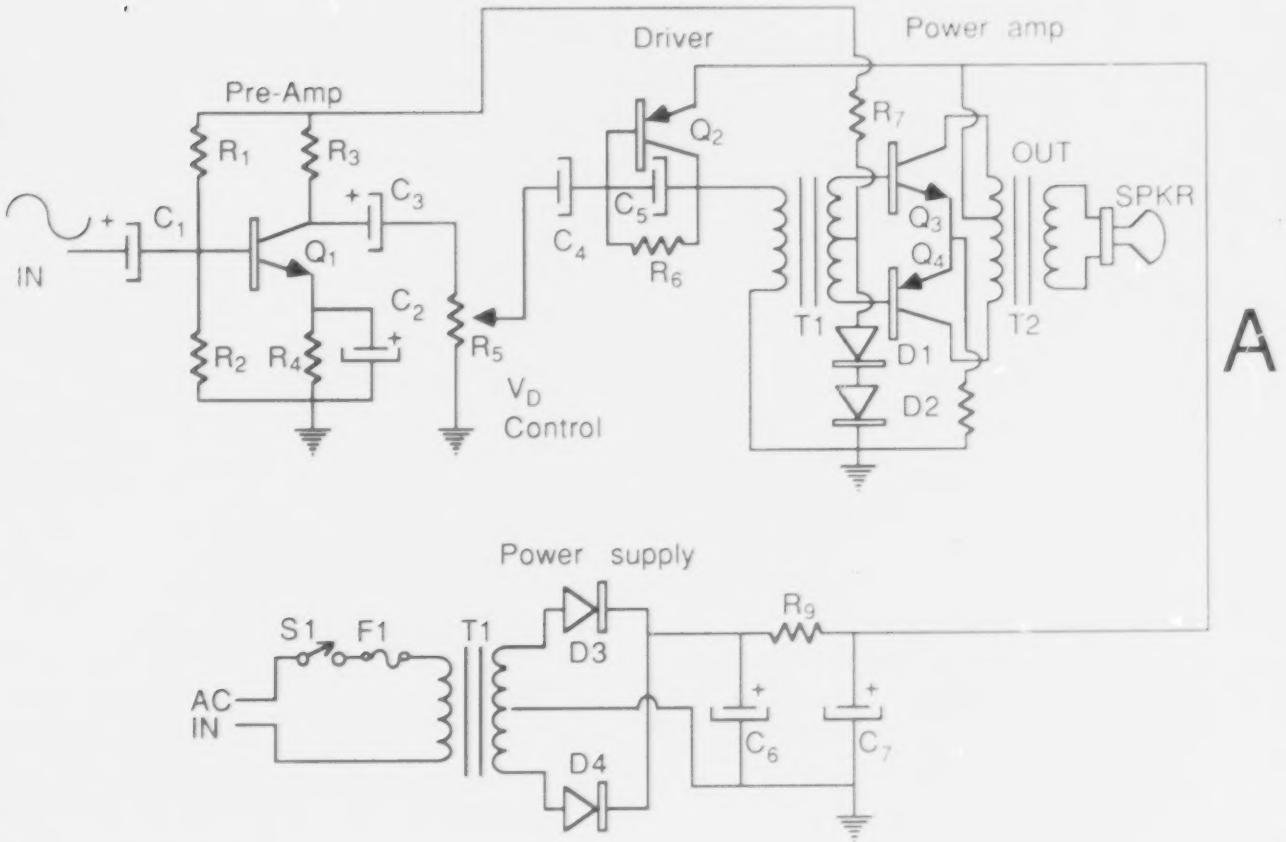
   d. Electromechanical transducer

AUDIO AMPLIFIER

B



A



AUDIO AMPLIFIER BLOCK DIAGRAMS

1. What do the arrows represent on audio amplifier block diagrams?

2. Do audio amplifier block diagrams show what amplifier configuration or class of amplifier make up a circuit? (Yes / no) Explain your answer.

3. The input signal is shown coming in to the _____ side, and the output is shown on the _____ side of both schematic and block diagrams.

4. Examine the audio amplifier block diagram in HO 2.1. Describe the audio amplifier operation from the information given in the block diagram.

5. Use a pencil to sketch a box around the component parts shown on the schematic diagram. Place a box around the parts that would be included in each block on the block diagram.

   Obtain from the instructor a schematic diagram of an audio amplifier used in your shop.

6. Draw and label a block diagram for that audio amplifier.

7. Describe the operation of the audio amplifier using the block diagram that you drew.

ANSWERS TO AS 2.1

1. Arrows represent the direction of signal flow.
2. No; block diagrams show what the circuit does, not what parts make up the circuit.
3. _LEFT_ _RIGHT_
4-7. Instructor to evaluate

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

LESSON 3: RADIO RECEIVER BLOCK AND SCHEMATIC DIAGRAMS

NOTE: After this lesson, the student should be able to follow signal flow through the system and explain the interaction of sections of the system.

I. Schematic diagram **(HO 3.1A)**

A. Circuit shown in detail

1. Schematic symbols for all component parts
2. Interconnection of each part

B. Input

1. The exact circuit is shown.
2. The antenna is the signal source shown on the receiver.
3. Current path can be traced through input circuit.

C. Output

1. The exact circuit is shown.
2. Loudspeaker output is shown on the receiver.
3. Current path can be traced through the output circuit.

D. Each amplifier stage between input and output

1. Schematic symbols of each component part
2. Circuit arrangement of each amplifier stage to show how each stage connects to adjacent stage

E. Circuits within each stage

1. Schematic symbols of each component part
2. Circuit arrangement of each component part
   a. Shows how stage works
   b. Identifies amplifier configuration

F. Direction of signal flow

1. By convention, the signal moves from left to right.
2. Schematic diagrams are drawn to show signal flow from left to right.

3. The receiver's schematic shows signal flow from antenna to loudspeaker.

G. Analysis of receiver schematic diagram

1. Antenna

   a. Input: RF signal from radio station

   b. Function: intercept RF signal

   c. Output: to mixer stage

   d. The antenna coil is part of the mixer stage.

2. Mixer stage

   a. Input: two inputs--RF signal from antenna coil and RF signal from oscillator stage

   b. Function: heterodyne-received RF signal and oscillator signal to select station and provide sensitivity

   c. Output: IF frequency to first IF amplifier

   d. Combines mixer and oscillator functions in one NPN transistor

   e. Q_1, C_1, L1 and T1 primary part of mixer circuit

3. Local oscillator stage

   a. Input: DC power from power supply

   b. Function: generate RF signal to heterodyne against received signal

   c. Output: RF carrier signal

   d. Carrier frequency separated from received signal by IF frequency difference

   e. Q_1, C_1 and L2 part of oscillator circuit

4. First IF amplifier stage

   a. Inputs: IF signal from mixer, DC control voltage from AGC circuit

   b. Function: provide selectivity, sensitivity and gain

   c. Output: amplified IF signal to second IF amplifier stage

   d. Q_2, T1 secondary; T2 primary part of first IF amplifier stage

5. Second IF amplifier stage

   a. Input: IF signal from first IF stage

   b. Function: provide additional selectivity and gain

   c. Output: IF signal to detector stage

   d. Q_3, T2 secondary; T3 primary part of second IF amplifier stage

6. Detector stage
    a. Input: IF signal from second IF amplifier stage
    b. Function: convert modulated IF signal to AF signal
    c. Output: AF signal to volume control circuit and AGC stage
    d. D1, T3 secondary; C_{10} part of detector stage
7. AGC stage
    a. Input: AF signal from detector stage
    b. Function: regulate gain of first IF amplifier for more constant volume level
    c. Output: DC control voltage to first IF amplifier
    d. R_{11}, C_4 and C_9 part of AGC stage
    e. Converts AF signal to DC control voltage in proportion to received signal strength
8. Volume control
    a. Input: audio signal from detector stage
    b. Function: control signal level to next stage
    c. Output: audio signal to audio amplifier stage
    d. easy to find test point
9. Audio amplifier stage
    a. Input: AF signal from volume control circuit
    b. Function: amplify and invert AF signal
    c. Output: AF signal to driver amplifier stage
    d. Q_4, NPN common-emitter amplifier
10. Driver amplifier stage
    a. Input: AF signal from audio amplifier stage
    b. Function: amplify and invert AF signal
    c. Output: AF signal to output amplifiers
    d. Q_5, PNP common-emitter amplifier
11. Output amplifier stages
    a. Input: AF signal from driver amplifier stage
    b. Function: provide AF power to loudspeaker

c. Output: AF signal current to loudspeaker

d. Complementary-symmetry amplifier configuration consisting of Q_6, NPN transistor, Q_7 and PNP transistor

12. Loudspeaker section

a. Input: audio signal power from power amplifier stage

b. Function: convert audio to sound

c. Output: sound

d. Electromechanical transducer

13. Power supply section

a. Battery for receiver power supply

b. Function: supply DC power for all receiver stages

c. Output: 9V DC

d. SW1 and C_{14} part of power supply section

II. Block diagram **(HO 3.1B)**

A. Same receiver

1. Functional form instead of component form

2. Each stage or section shown as a block

B. Input

1. Shown as arrow pointing into block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from another place to the input of this block

C. Output

1. Shown as arrow pointing out of block

2. Labeled with signal, data or voltage present

3. Indicates that voltage comes from this block and goes to another place or block

D. Circuitry between input and output

1. Not shown in detail

2. Shows functional stage or section

3. Shows only function of block, not how the stage works

E. Direction of signal flow

1. By convention, the signal moves from left to right.
2. Block diagrams are drawn to show signal flow from left to right.
3. The receiver block diagram shows signal flow from antenna to loudspeaker.
4. AGC control voltage is shown coming from a later stage (AGC) and going to a previous stage (first IF amplifier).

F. Analysis of receiver block diagram

1. Antenna
   a. Input: RF signal from radio station
   b. Function: intercept RF signal
   c. Output: to mixer stage
2. Mixer block
   a. Input: two inputs--RF signal from antenna coil and RF signal from oscillator block
   b. Function: heterodyne-received RF signal and oscillator signal to select station and provide sensitivity
   c. Output: IF frequency to first IF amplifier block
   d. Does not show that mixer and oscillator functions are combined in one transistor
   e. Shows that block is dependent upon two inputs to work properly
   f. Two inputs not easily observed on schematic diagram
3. Local oscillator block
   a. Input: DC power from power supply
   b. Function: generate RF signal to heterodyne against received signal
   c. Output: RF carrier signal
   d. Carrier frequency separated from received signal by IF frequency difference
4. First IF amplifier block
   a. Input: IF signal from mixer, DC control voltage from AGC circuit
   b. Function: provide selectivity, sensitivity and gain
   c. Output: amplified IF signal to second IF amplifier block
   d. Shows that block is dependent upon two inputs to work properly
   e. Two inputs not easily observed on schematic diagram

5. Second IF amplifier block

   a. Input: IF signal from first IF block

   b. Function: provide additional selectivity and gain

   c. Output: IF signal to detector block

6. Detector block

   a. Input: IF signal from second IF amplifier block

   b. Function: convert modulated IF signal to AF signal

   c. Output: AF signal to volume control circuit and AGC block

7. AGC block

   a. Input: AF signal from detector block

   b. Function: regulate gain of first IF amplifier for more constant volume level

   c. Output: DC control voltage to first IF amplifier block

   d. Converts AF signal to DC control voltage in proportion to the received signal strength

8. Volume control

   a. Input: audio signal from detector block

   b. Function: control signal level to next block

   c. Output: audio signal to audio amplifier block

   d. Easy to find test point

9. Audio amplifier stage

   a. Input: AF signal from volume control circuit

   b. Function: amplify and invert AF signal

   c. Output: AF signal to driver amplifier block

10. Driver amplifier block

   a. Input: AF signal from audio amplifier block

   b. Function: amplify and invert AF signal

   c. Output: AF signal to output amplifier blocks

11. Output amplifier blocks

   a. Input: AF signal from driver amplifier block

   b. Function: provide AF power to loudspeaker

c. Output: AF signal current to loudspeaker

d. Shows output is some type of push-pull amplifier but not that it is a complementary-symmetry amplifier configuration

e. Could use one output amplifier block

12. Loudspeaker section

a. Input: audio signal power from power amplifier block

b. Function: convert audio to sound

c. Output: sound

d. Electromechanical transducer

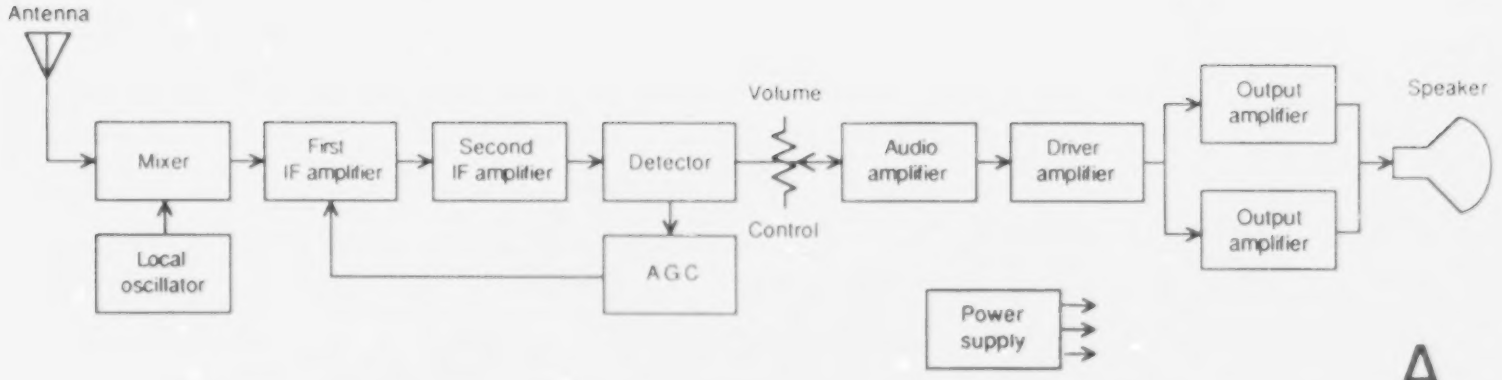
13. Power supply block

a. Input: none shown on block

b. Function: supply DC power for all receiver blocks

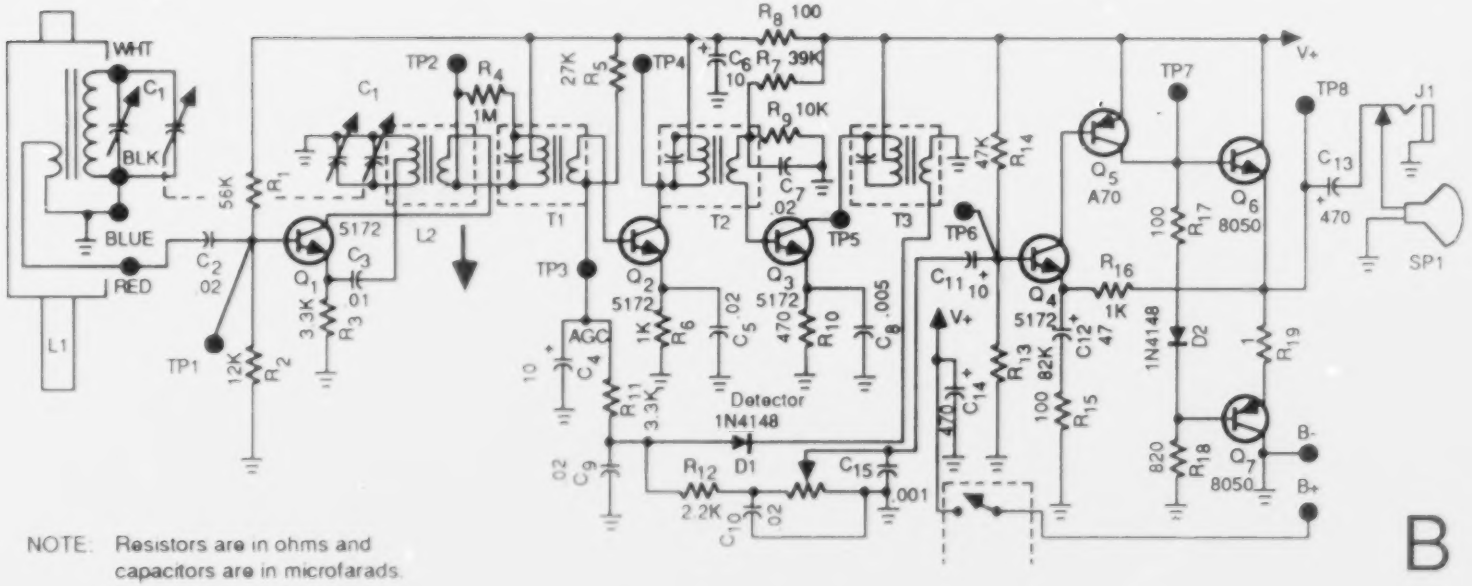
c. Output: 9V DC to all blocks

d. Does not necessarily show that battery is power supply for receiver



A

Circuit diagram



NOTE: Resistors are in ohms and capacitors are in microfarads.

B

AM RADIO RECEIVER

HO 31

RECEIVER BLOCK DIAGRAMS

1. Why does a power supply block appear on a receiver block diagram?

2. Do receiver block diagrams show which amplifier configuration or class of amplifier make up a circuit? (Yes / no) Explain your answer.

3. The input signal is shown as a(n) _____ signal coming in to the _____ side, and the output is shown as a(n) _____ signal on the _____ side of the receiver block diagram.

4. Examine the receiver block diagram in HO 3.1. Describe the receiver operation from the information given in the block diagram.

5. Use a pencil to sketch a box around the component parts shown on the schematic diagram. Place a box around the parts that would be included in each block on the block diagram.

   Obtain from the instructor a schematic diagram of a receiver used in your shop.

6. Draw and label a block diagram for that receiver.

7. Describe the operation of that receiver using the block diagram that you drew.

ANSWERS TO AS 3.1

1. For the circuits to operate, all electronic equipment must have a power supply--either an AC power supply or a battery. Without power, no circuit would function.

2. No; block diagrams show what the circuit does, not what parts make up the circuit.

3. _RF_ _LEFT_ __AUDIO_ _RIGHT_

4-7. Instructor to evaluate

MODULE: TESTING AND TROUBLESHOOTING

UNIT I: BLOCK DIAGRAMS

UNIT TEST

Mark true statements with an "a" and false ones with a "b".

____ 1. Block diagrams show what a circuit does.

____ 2. Signal flows from right to left in a block diagram.

____ 3. All electronic systems must have a power supply.

____ 4. The block diagram in Figure 1 *(see next page)* shows a push-pull power amplifier.

____ 5. A block diagram shows how the component parts are connected.

____ 6. All of the right channel of Figure 1 could be represented by a single block.

____ 7. A schematic diagram shows how the component parts are connected.

____ 8. The power supply in Figure 1 has DC at the block input.

____ 9. The Figure 2 schematic shows four diodes in a half-wave rectifier.

____ 10. Figure 2 is a functional block diagram.

Select the option which answers the question or completes the statement.

____ 11. What kind of system is shown in the block diagram in Figure 1?

a. Power supply
b. Radio receiver
c. Audio amplifier
d. Stereo audio amplifier
e. Both a and b

____ 12. What does the balance control in Figure 1 affect?

a. Only the left channel
b. Only the right channel
c. Both left and right channels
d. Only the power supply
e. None of the above

____ 13. The system shown in Figure 1 could be divided into three major sections. What are they?

a. Pre-amp, amplifier, driver
b. Pre-amp, amplifier, power amplifier
c. Volume control, balance control, loudspeaker
d. Pre-amp, driver, power amplifier
e. Left channel, Right channel, power supply

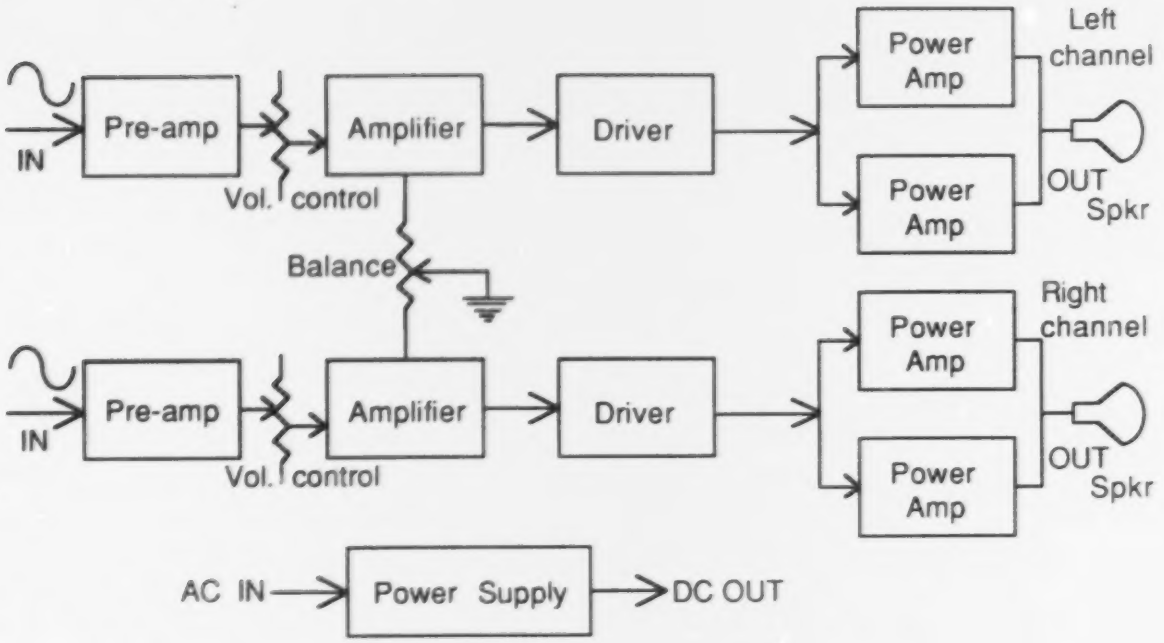


Figure 1

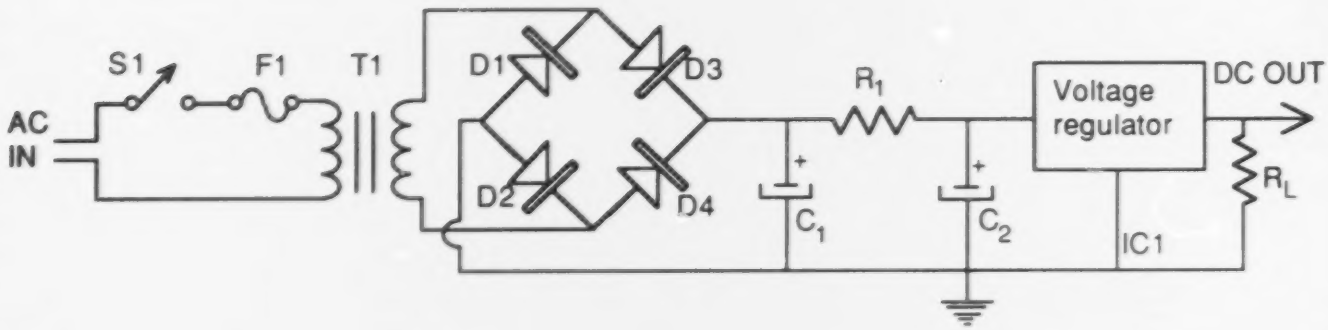


Figure 2

___ 14. The Figure 1 left-channel driver amplifier has input signal from which block?

a. Pre-amp
b. Power supply
c. Amplifier
d. Power amplifiers
e. Loudspeaker

___ 15. If there were no DC voltage from the power supply in Figure 1, what would be affected?

a. Only the left channel
b. Only the right channel
c. Both left and right channels
d. Only the power supply
e. Balance control

___ 16. The Figure 1 right-channel power amplifier has input signal from which block?

a. Pre-amp
b. Driver
c. Amplifier
d. Left channel power amplifier
e. Power supply

___ 17. What do block diagrams show the technician?

a. How sections of the system are interconnected
b. How component parts of the system are connected
c. The path that signals follow from input to output
d. The configuration of each individual amplifier
e. Both a and c

18. **Draw a block diagram.** (10 points)

Analyze Figure 2, then draw and label a functional block diagram of the system.

Your block diagram . . .

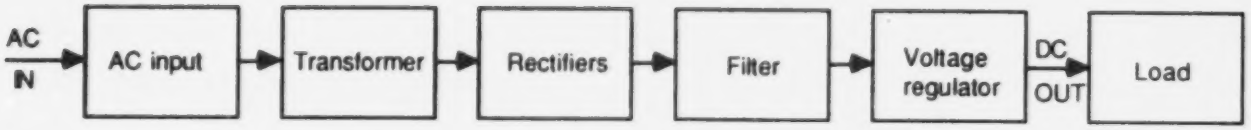
19. **Analyze a block diagram.** (5 points)

Using your block diagram, write a description of how the system works.

ANSWERS TO UNIT TEST (N1)

1. a
2. b
3. a
4. a
5. b
6. a
7. a
8. b
9. b
10. b
11. d
12. c
13. e
14. c
15. c
16. b
17. e

18.



19. AC is applied through switch and fuse to primary of transformer.
Transformer steps AC voltage up or down.
Rectifiers change AC to DC.
Filter smoothes ripple out of DC.
Regulator I.C. holds output voltage to a constant value.
Load represents circuits using power from the power supply.

MODULE: TESTING AND TROUBLESHOOTING

UNIT II: BOARD-LEVEL REPAIRS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to explain and demonstrate a logical step-by-step method of board-level troubleshooting while repairing and testing a defective electronics system. This knowledge will be evidenced by satisfactory completion of the job sheets and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit the student should be able to:

1.1 Define terms and definitions related to symptom diagnosis.

1.2 Demonstrate a logical method of board-level troubleshooting.

1.3 Identify problem area of defective system by symptom diagnosis. (JS 1.1)

1.4 Use troubleshooting aids. (JS 1.1)

1.5 Apply the divide-and-conquer procedure. (JS 1.1)

1.6 Practice troubleshooting to board level using the major troubleshooting assumption. (partial competency N2, JS 1.1)

2.1 Define terms and definitions.

2.2 Test system for proper operation after repair. (JS 2.1)

2.3 Describe after-repair procedures, such as preparing a job ticket and bill for services. (AS 2.1)

2.4 Describe good service-call techniques.

2.5 Perform board-level repair on defective unit. (partial competencies N2 and N5, JS 2.1)

MODULE: TESTING AND TROUBLESHOOTING

UNIT II: BOARD-LEVEL REPAIRS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: SYMPTOM DIAGNOSIS

   a. Information outline

   b. Handout

      HO 1.1: Troubleshooting flow chart

   c. Job sheet

      JS 1.1: Practice troubleshooting to board level

2. Lesson 2: POST-REPAIR TESTING

   a. Information outline

   b. Assignment sheet

      AS 2.1: Fill out job ticket

   c. Answers to assignment sheet

   d. Job sheet

      JS 2.1: Perform board-level repair

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Brenner, Robert C. IBM PC Advanced Troubleshooting and Repair. Indianapolis, IN: Howard W. Sams & Co. Inc., 1988.

2. Cook, Nigel P. Introductory DC/AC Electronics. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

3. Frenzel, Louis E. Communication Electronics. St. Louis: McGraw-Hill, 1989.

4. Grob, Bernard. Basic Electronics. 6th ed. New York: McGraw-Hill, 1989.

5. Mager, Robert F. Troubleshooting the Troubleshooting Course or Debug d'Bugs. Belmont, CA: David S. Lake Publishers, 1982.

6. Paynter, Robert T. Introductory Electronic Devices and Circuits. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

7. Schuler, Charles A. Electronics: Principles and Applications. 3rd ed. New York: McGraw-Hill, 1989.

8. Tokheim, Roger L. Digital Electronics. 3rd ed. New York: McGraw-Hill, 1989.

9. PhotoFacts Index. Indianapolis, IN: Howard W. Sams & Co., Inc., 1990.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1980.

3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Discuss logical approach to troubleshooting.

2. Discuss the two levels of repair.

3. Explain the use of troubleshooting aids, such as factory service manuals, commercial schematic services, block diagrams, flow charts and built-in diagnostics.

4. While students practice troubleshooting, allow them to use job sheets as student guides. Then take away the job sheets and use them as evaluation instruments as students perform board-level repairs.

B. Suggested student activities

1. Practice symptom diagnosis to identify problem area or board.

2. Troubleshoot an electronic system to board level.

C. Suggested supplemental materials

1. PhotoFacts Index. Indianapolis, IN: Howard W. Sams & Co., Inc., 1990. (Includes "ComputerFacts" listing for various computers, printers, disk drives and CRT displays. Available from electronics wholesale outlets)

2. Digital Troubleshooting (video, E-89-369). Sedalia, MO: The Media Center, State Fair Community College, 1989. (Available for purchase from SFCC; available for loan from Missouri Vocational Resource Center, phone 800/392-7217 or 314/882-9610)

MODULE: TESTING AND TROUBLESHOOTING

UNIT II: BOARD-LEVEL REPAIRS

LESSON 1: SYMPTOM DIAGNOSIS

I. Terms and definitions

A. Board-level repair--repair method of finding and replacing a defective circuit board, module or sub-assembly

B. Divide and conquer--technique of dividing system into working and non-working sections; also called the "half-split" method. The technique is repeated until the defective section or circuit board is found.

C. Major troubleshooting assumption--Assume that only one thing is causing the observed problem, then troubleshoot to find that one thing.

D. Symptom--indicators that something is wrong in a system: no sound, distorted sound, smoke, no picture, hum, etc.

E. Symptom diagnosis--procedure of analyzing symptoms and using a knowledge of system function and block diagrams to determine a probable defective section or circuit board

II. Board-level repair by module or sub-assembly replacement

A. Widely used in industry

1. Service calls at customer location
2. Service department at retail store
3. Factory field service technicians

B. Advantages

1. Less technical training required
2. Immediate customer satisfaction
3. Equipment quickly restored to service
4. Usually done at customer location
5. Can complete several repair jobs in less time; more profit for service company
6. Lower labor charge since less time is spent on job

C. Disadvantages

1. Maintaining an inventory of the required replacement circuit boards is expensive.
2. The exchange price is given for rebuilt or new cards, even if the problem is only a burned out resistor or transformer.

3. Dealers pay for cards used in warranty repairs.

   a. Delay in receiving money from factory

   b. May get board replaced instead of cash

4. Buying a replacement board instead of the defective component results in a customer's higher parts cost.

5. Many expensive sub-assemblies are discarded and considered "throw away".

D. Not practical on some equipment

1. Older equipment

2. Equipment that is not modular-built

III. Identifying problem area or board by symptom diagnosis **(HO 1.1)**

A. Use the two-step, general approach to board-level troubleshooting.

1. Identify problem area, section or board by symptom diagnosis.

   a. Use block diagrams.

   b. Use troubleshooting flow charts.

2. Test for proper operation after repair.

B. Analyze defective system.

1. What is the system supposed to do?

   a. Supply DC power? (One or more source[s]? Interlocked or stacked power supplies?)

   b. Amplify audio signals?

      (1) Monaural sound?

      (2) Stereo sound?

      (3) Record turntable?

      (4) CD player?

      (5) Cassette player? (Play back? Record?)

   c. Receive radio stations?

      (1) AM broadcast? (Monaural or stereo?)

      (2) FM broadcast? (Monaural or stereo?)

      (3) Both AM and FM broadcast?

      (4) CB?

(5) Aircraft?

(6) Police?

(7) Other communications?

d. Receive television stations?

(1) Black and white?

(2) Color?

(3) Stereo sound or monaural?

(4) Remote control or manual?

(5) How many channels? (Local station or cable?)

e. Video recorder?

(1) Record?

(2) Playback?

(3) Stereo sound or monaural?

(4) Remote control or manual?

(5) How many channels? (Local station or cable?)

f. Computer?

(1) Monochrome?

(2) Color?

(3) Graphics?

(4) Cassette?

(5) Floppy disk?

(6) Hard disk?

(7) Modem?

(8) Printer?

g. Copy machine?

(1) Any paper?

(2) Special paper?

(3) Reduce?

(4) Enlarge?

(5) Color?

(6) Multiple copies?

C. Observe symptoms.

1. Dead

a. Nothing works at all

b. No sound

c. No picture

2. Part of system works

a. One stereo channel

b. Picture, no sound on TV

c. Sound, no picture on TV

d. Recorder plays back, does not record

e. Recorder records, does not play back

f. Computer can use only one disk drive

g. Computer works but will not print

h. Can play tapes, radio does not work

3. Intermittent

a. Works for short time then quits

b. Quits when it gets hot

c. Quits or starts working when jarred

d. Quits for no apparent reason

e. Works with one operator, but will not work with another operator

D. Analyze observations.

1. What does work normally

2. What does not work

3. What could cause this problem

E. Use the major troubleshooting assumption.

1. What one defective section could cause this problem?

2. Always troubleshoot one problem at a time.

3. If there appears to be more than one problem, find the major problem first. Then observe symptoms again.

   a. Find the next problem. Look for the one thing to cause the failure.

   b. Continue until troubles are all removed.

4. "If it ain't broke, don't fix it". Apply a logical method to troubleshooting.

   Examples: If a car radiator is boiling over, don't change the left rear tire; do work on the cooling system.

   If the left stereo channel is dead, don't work on right channel; do work on the left channel.

   If the FM radio is dead but cassette plays OK, don't work on audio power amplifiers; do work on the FM radio section.

F. Talk to the appropriate owner, user or operator.

1. Questions

   a. When did they notice the trouble?

   b. Exactly what did they observe?

   c. Were they performing a normal operation? Did the system perform well on previous operations? Did the operator do something different?

2. Is the problem legitimate or simply an operator error? Observe the operator to see if his/her procedure is correct.

3. Try to duplicate operator findings.

4. Look for common occurrences related to system failure.

G. Perform inspection.

1. Keep parts and hardware in a container to prevent part loss, part damage or shorts in equipment caused by loose parts.

2. Use all of your senses.

   a. Visually inspect parts and board. Is the video absent or distorted? Is the color absent or wrong?

   b. Use the sense of touch to find excessive heat and loose components.

   c. Listen for a hum, mechanical or electronic noise, or distorted audio.

   d. Use smell to detect overheated parts. Their distinctive odor can indicate excessive heat and shorts.

3. Check the power. Is the power cord connected, switch turned on and fuse in fuse holder?

4. Check cables and plugs for breaks or loose connections. Check that plugs are seated on connectors.

5. Circuit boards can have several problems.

   a. Correct boards

   b. Boards plugged in securely

   c. Missing boards

   d. Charred board

   e. Loose screws or wires causing shorts

6. Component parts can be broken, missing, burned or bent (causing a short).

IV. Troubleshooting aids

A. Use block diagrams.

1. Actual block diagram are best, if available.

2. Sketch general block of system if none is available.

B. Use built-in diagnostics.

1. Some equipment will diagnose itself by giving an error code.

2. Look up the error code in manuals.

C. Use troubleshooting flow charts.

V. Divide and conquer

A. Never try to troubleshoot the whole system.

1. Divide the system into rough halves.

2. As you proceed, divide again and again.

B. Using the block diagram, divide the system into two major sections--working and non-working.

C. A minimum of test equipment is used at this point.

1. Use built-in indicators, if possible (sound from the loudspeaker, CRT raster or video, self-test diagnostic).

2. Use the oscilloscope sparingly with the signal tracing method. (See next unit.)

   CAUTION: Observe grounding safety rules when using the oscilloscope. An isolation transformer is required when using the oscilloscope.

   a. Trace signal through major sections.

   b. Start at the system's input.

   c. Follow signal toward output.

3. Signal generators can be used sparingly with the signal injection method.

   a. Inject signal through major sections.

   b. Start at the system's output.

   c. Inject signal toward the input.

4. Voltmeters can be used often.

   a. Test power supply voltages to make sure the power supply is OK.

   b. If voltage is not getting to a section or board, the problem can be the power supply, not the board.

   c. If voltage is getting to a section or board, the problem may be that section or board.

VI. Major troubleshooting assumption applied to component-level troubleshooting

A. Look for the <u>one</u> section causing the problem.

B. Narrow the search.

1. Symptom diagnosis is not intended to find actual defect but the defective section or circuit board.

2. Symptom diagnosis narrows the search. Start with whole system, divide and conquer to the section or board level.

C. Try a "quick fix".

1. Swap out a suspect board.

   CAUTION: Do <u>not</u> put a suspected faulty board into working equipment; the defective board can cause damage to the good equipment.

2. If that does not work, swap out another.

D. When the defective board is found, replace the defective board or module.

E. Test for proper operation.

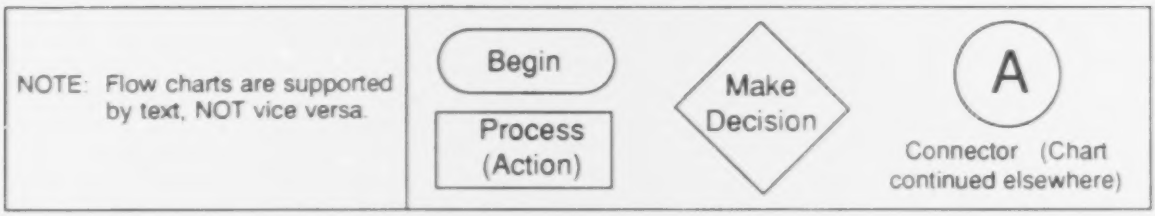
F. If the defective board is still not found, apply the four-step method (Unit III).

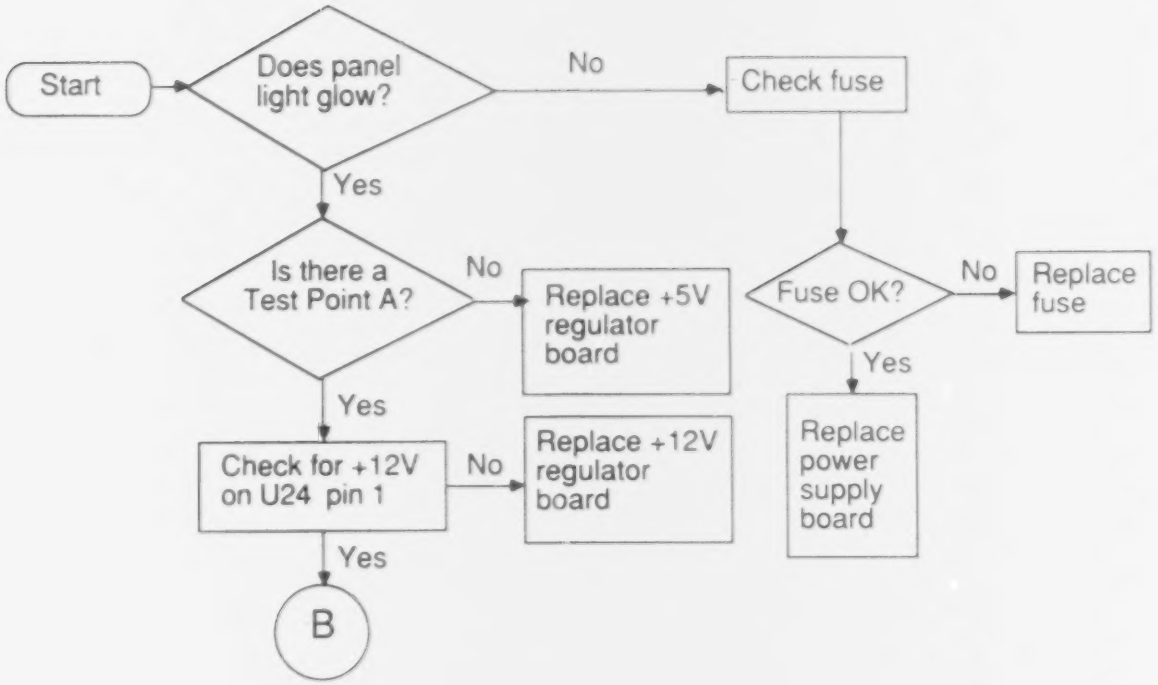
G. If the defective board is to be repaired at the component level, the section will be divided again.

1. See Unit III for details.

2. Divide and conquer again.

TROUBLESHOOTING FLOW CHART





PRACTICE TROUBLESHOOTING TO BOARD LEVEL

NOTE: Ask the instructor for equipment to practice board-level troubleshooting procedures.

Equipment description: _____

Model #: _____ Serial #: _____

Procedure:	Evaluation 3	2	1	N
1. Analyze defective system.	—	—	—	—
2. Observe symptoms.	—	—	—	—
3. Analyze observations.	—	—	—	—
4. Use the major troubleshooting assumption.	—	—	—	—
5. Perform inspection.	—	—	—	—
6. Use troubleshooting aids.	—	—	—	—
7. Use divide-and-conquer technique.	—	—	—	—
8. Make proper use of test equipment.	—	—	—	—
9. Try a quick fix.	—	—	—	—
10. Identify the defective board or module.	—	—	—	—
11. Replace defective board or module.	—	—	—	—
12. Use safe troubleshooting procedure.	—	—	—	—
13. Clean up work area.	—	—	—	—
14. How long did it take to perform this procedure? Hours _____ Minutes _____	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's partial evaluation for competency N2: Identify problem area by symptom.

MODULE: TESTING AND TROUBLESHOOTING

UNIT II: BOARD-LEVEL REPAIRS

LESSON 2: POST-REPAIR TESTING

I. Terms and definitions

A. Cook out--operating the repaired electronic equipment for at least one hour before proclaiming the system repaired

B. Call back--to rework a repair job because the problem was not found the first time

C. Service call--trip to customer location for on-site repair or pick-up and delivery of equipment

II. Testing for proper operation after repair

A. After replacement of defective board or module

1. Test unit for proper operation.

a. Check all functions for normal operation.

b. Check all controls for normal operation.

c. Check for original problem.

2. Cook out unit for at least one hour.

a. Check for normal operation.

b. Be sure that original problem does not return.

c. Check for any new problem. Heat build-up can cause another problem. Also, the original malfunction may have covered up another problem.

d. Start on another job while the unit cooks out.

B. If problem appears

1. Apply the major troubleshooting assumption. Assume that one defective part is causing problem and troubleshoot to find that one defect.

2. Identify the problem area, section or board by symptom diagnosis.

C. If the defective board is still not found, apply the four-step method. (See Unit III for details.)

III. After-repair procedures

A. Perform preventive maintenance.

1. Do technician-level preventive maintenance.

2. Show the operator how to do customer-level maintenance.

B. Reassemble repaired unit.

1. Blow dust out of unit with shop vacuum cleaner.
2. Replace all covers.
3. Replace all screws.
4. Check that all cables, etc., are with the unit.
5. Replace all knobs and trim.
6. Always make one last test after reassembly.
    a. Screws can short something out.
    b. Cable connectors can pull loose.
    c. Do not send the unit out with a new problem.

C. Cook out unit as long as possible.

1. Reduces call backs and call backs reduce profit
2. Improves public relations (did the job right the first time)

D. Fill out work order or job ticket.

1. List job information such as customer name, equipment model and serial number, work done and technician's name.
2. Itemize all parts used. List the price of each part and the sales tax on parts.
3. Include labor and/or service charges (hourly or flat rate charge, pick-up and delivery charges, service call).
4. Total all charges.

IV. Service call

A. Return equipment.

1. Install equipment.
2. Verify that equipment works.
3. Present work order to customer.
    a. Have the customer sign the bill.
    b. Collect a check for the bill, if required.
    c. Mark bill PAID if the customer pays you.
    d. Give customer the original (top) ticket.

4. Perform work in a timely manner.

   a. Time is valuable for the technician, the employer and the customer. Work done in a timely manner results in improved customer relations.

   b. If with the customer for more than 20-30 minutes, be prepared to justify the time. Examine your work habits.

B. Act like a professional.

1. Be neat and clean in appearance.
2. Be honest; do only repairs that are needed.
3. Be fair; work quickly in a professional manner.
4. Do not joke or talk too much; do not brag.
5. Be positive toward yourself, the employer, a competitor and the customer.
6. Find another job to work on.

   a. Keep busy.

   b. Earn your pay.

   c. Be honest with your employer.

   d. Be fair with your employer.

   e. Make yourself an asset to the employer.

JOB TICKET

You are the owner and technician of Acme Electronic Repair. Your service rates are:

Service call (including 30 minutes at customer site)	$55.00
Hourly labor (One hour minimum; over one hour charged in quarter-hour increments)	$40.00
Parts: Disk drive	$129.00
Printer cable, 10 ft.	$32.50

Problem:

Mr. Smith, the assistant manager at Ace Construction Company, called to say that his computer would not read or save anything to floppy disk drive B. Mr. Smith says that the accountant has notice that since he tripped over the printer cable two days ago, the printer works only for a short time. If the accountant wiggles the cable, the printer will start working again. He asks if you could come out to the office immediately because the accountant is doing the payroll. You tell Mr. Smith that you are on the way.

From the description on the phone, you suspect that the disk drive is defective, so you put a new drive and printer cable in the service truck. You make the service call to Ace, arriving at 9:45 a.m. After diagnosis you determine that the floppy disk drive is indeed defective.

By 11 a.m. the new drive is installed and the computer tested. You also find that the printer cable has several wires pulled loose from the connector. The connector is the solderless, crimped type. While you are there you use a portable vacuum cleaner and blow dust out of the computer and the printer. You use a cleaning diskette on drive A. After replacing covers, screws and cables you have the computer operator verify that the computer operates normally. The computer is an IBM PC, Model 5150 and the serial number is N52689. It is now 11:15 a.m.

Work Order
ACME ELECTRONIC REPAIR
999 Any Street
Anytown, USA 99999-9999

Customer Name		Business/Address	
Telephone			
Description	Model #	Serial #	
Work Done			Date
			CHARGES Parts
Parts Used			
			Labor
Labor			
			Subtotal
Customer's Approval			
			Tax
Technician			TOTAL
On Site	Shop	Service Contract	

Assignment:

Make out the work order and present it to Mr. Smith. (Charge 5% tax.) Mr. Smith gives you a company check for the full amount.

ANSWERS TO AS 2.1

The student's work order should be similar to the following.

Work Order
ACME ELECTRONIC REPAIR
999 Any Street
Anytown, USA 99999-9999

Customer Name: JAY SMITH	Business/Address: ACE CONSTR. COMPANY MAIN STREET ANY TOWN, USA 99999
Telephone: 555-5549	

Description	Model #	Serial #
IBM-PC	5150	N52689

Work Done: Test and replace floppy drive B Test and replace printer cable Cleaned drive A and printer	Date: 3/14/90
Parts Used: 1 floppy disk drive 1 10 Ft. long printer cable	CHARGES Parts: $129.00 32.50
Labor: Service call + ½ hr labor @ $55.00 1 hr additional labor at $40.00	Labor: $95.00
Customer's Approval: M. Smith	Subtotal: $256.50
Technician	Tax: $12.83
On Site ✓ / Shop / Service Contract	TOTAL: $269.33

NOTE: The student's name should be on the ticket as the technician.

PERFORM BOARD-LEVEL REPAIR

NOTE: Ask the instructor for equipment to practice board-level troubleshooting.

Equipment description: _____

Model #: _____ Serial #: _____

Procedure:		Evaluation 3	2	1	N
1.	Analyze defective system.	—	—	—	—
2.	Observe symptoms.	—	—	—	—
3.	Analyze observations.	—	—	—	—
4.	Use the major troubleshooting assumption.	—	—	—	—
5.	Perform inspection.	—	—	—	—
6.	Use troubleshooting aids.	—	—	—	—
7.	Use divide-and-conquer technique.	—	—	—	—
8.	Make proper use of test equipment.	—	—	—	—
9.	Try a quick fix.	—	—	—	—
10.	Identify the defective board or module.	—	—	—	—
11.	Replace defective board or module.	—	—	—	—
12.	Test the repaired unit.	—	—	—	—
13.	Clean and adjust repaired unit.	—	—	—	—
14.	Replace covers, screws and cables.	—	—	—	—
15.	Make final unit test.	—	—	—	—
16.	Cook out repaired unit.	—	—	—	—
17.	Clean up work area.	—	—	—	—
18.	Fill out work order or job ticket	—	—	—	—

Work Order
ACME ELECTRONIC REPAIR
999 Any Street
Anytown, USA 99999-9999

Customer Name		Business/Address
Telephone		
Description	Model #	Serial #
Work Done		Date
		CHARGES Parts
Parts Used		
		Labor
Labor		
		Subtotal
Customer's Approval		
		Tax
Technician		TOTAL
On Site / Shop / Service Contract		

19. How long did it take to perform this procedure? — — — —
Hours: _____ Minutes: _____

Average of above evaluations* — — — —

*This average is the student's partial evaluation for competencies N2 and N5.

MODULE: TESTING AND TROUBLESHOOTING

UNIT II: BOARD-LEVEL REPAIRS

UNIT TEST

Match the following terms and definitions.

____ 1.	Procedure of analyzing symptoms and using a knowledge of system function and block diagrams to determine a probable defective section or circuit board	a.	Board-level repair
____ 2.	Technique of dividing system into working and non-working sections; also called the "half-split" method	b.	Call back
____ 3.	Method of finding and replacing a defective circuit board, module or sub-assembly	c.	Cook out
____ 4.	Operating the repaired electronic equipment for at least one hour before proclaiming the system repaired	d.	Divide and conquer
____ 5.	Reworking a repair job because the problem was not found the first time	e.	Major trouble-shooting assumption
____ 6.	Trip to customer location for on-site repair or pick-up and delivery of equipment	ab.	Service call
		ac.	Symptom
		ad.	Symptom diagnosis

Mark true statements with an "a" and false ones with a "b".

____ 7. Board-level repairs result in more profit for the service company since several repair jobs can be completed in less time.

____ 8. Module replacement is preferred even on older equipment.

____ 9. Buying a replacement board instead of the defective component results in a lower customer parts cost because of mass-production.

____ 10. A technician should be prepared to justify all charges to a customer.

____ 11. Technicians should be positive toward themselves, their employer, a competitor or the customer.

____ 12. The technician's employer is usually responsible for filling in such work order details as part prices and service charges.

ANSWERS TO UNIT TEST

1. ad (N2)
2. d (N2)
3. a (N2)
4. c (N5)
5. b (N2)
6. ab (N2)
7. a (N2)
8. b (N2)
9. b
10. a
11. a
12. b

MODULE: TESTING AND TROUBLESHOOTING

UNIT III: COMPONENT-LEVEL TROUBLESHOOTING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to demonstrate a logical step-by-step method of troubleshooting, repairing and testing a defective electronics system to the chip- or component-level. This knowledge will be evidenced by satisfactory completion of the job sheets.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Demonstrate a logical method of component-level troubleshooting. (JS 1.1)

1.2 Locate the problem area to a stage or smaller section. (JS 1.1)

1.3 Demonstrate the signal-trace method. (JS 1.1)

1.4 Demonstrate the signal-injection method. (JS 1.1)

1.5 Develop a method or style of troubleshooting. (JS 1.1)

2.1 Isolate the defective unit, circuit and components. (competencies N2-5 and H1-3, JS 2.1)

2.2 Replace the defective part and test for proper operation. (JS 2.1)

MODULE: TESTING AND TROUBLESHOOTING

UNIT III: COMPONENT-LEVEL TROUBLESHOOTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: LOCATE TO STAGE OR SMALLER SECTION

   a. Information outline

   b. Handouts

      HO 1.1: Signal trace
      HO 1.2: Signal inject
      HO 1.3: Troubleshooting chart

   c. Job sheet

      JS 1.1: Practice troubleshooting to defective stage

2. Lesson 2: ISOLATE DEFECTIVE UNIT

   a. Information outline

   b. Job sheet

      JS 2.1: Isolate defective unit, circuit and components

REFERENCES

A. Books

1. Brenner, Robert C. IBM PC Advanced Troubleshooting and Repair. Indianapolis, IN: Howard W. Sams & Co. Inc., 1988.

2. Cook, Nigel P. Introductory DC/AC Electronics. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

3. Frenzel, Louis E. Communication Electronics. St. Louis: McGraw-Hill, 1989.

4. Grob, Bernard. Basic Electronics. 6th ed. New York: McGraw-Hill, 1989.

5. Mager, Robert F. Troubleshooting the Troubleshooting Course or Debug d'Bugs. Belmont, CA: David S. Lake Publishers, 1982.

6. Paynter, Robert T. Introductory Electronic Devices and Circuits. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall, 1989.

7. Schuler, Charles A. Electronics: Principles and Applications. 3rd ed. New York: McGraw-Hill, 1989.

8. Tokheim, Roger L. Digital Electronics. 3rd ed. New York: McGraw-Hill, 1989.

9. PhotoFacts Index. Indianapolis, IN: Howard W. Sams & Co., Inc., 1990.

B. Curriculum guides

1. Hartman, Lonnie. Basic Electronics. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

2. Robertson, L. Paul. Basic Electronics I. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1980.

3. Vorderstrasse, Ron. General Electronics Technician. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Discuss the use of block diagrams.

   a. Discuss signal or data flow between blocks.

   b. Discuss interaction of blocks within the diagram.

2. Explain use of troubleshooting schematics.

   a. Factory service manuals

   b. Commercial schematic services

3. Discuss troubleshooting technique.

   a. Starting with the whole system, diagnose the problem.

   b. Troubleshoot in an organized manner.

   c. Divide and conquer to identify the section.

   d. Divide and conquer to locate the stage.

   e. Divide and conquer to isolate the defective component.

   f. Replace parts.

4. Evaluate.

   a. Have student practice troubleshooting with job sheets.

   b. Take job sheets away from students during evaluation.

c. Use job sheets as evaluation instrument.

B. Suggested student activities

1. Trace signal and data flow through block diagrams.
2. Trace signal and data flow through schematic diagrams.
3. Practice signal-trace technique with good working units.
4. Practice signal-inject technique with good working units.
5. Practice using a signal generator, oscilloscope, VOM and component analyzer.
6. Roll-play a service call.

MODULE: TESTING AND TROUBLESHOOTING

UNIT III: COMPONENT-LEVEL TROUBLESHOOTING

LESSON 1: LOCATE TO STAGE OR SMALLER SECTION

NOTE: Both block diagrams and schematic diagrams are useful when locating a defective stage or small section using signal trace or injection test equipment.

I. Four-step method of troubleshooting to the component level

- A. Refer to the troubleshooting chart. **(HO 1.3)**
- B. **Identify** problem area, section or board by symptom diagnosis.
  1. Start with whole system.
  2. Divide and conquer to section.
  3. Use block diagrams.
  4. Use troubleshooting flow charts.
  5. Use test equipment and voltage tests minimally.
  6. Review Unit II if necessary.
- C. **Locate** problem area to a stage or smaller section.
  1. Divide and conquer to stage.
  2. Use block diagrams.
  3. Use schematic diagrams.
  4. Use signal trace or injection.
- D. **Isolate** problem area to the defective unit, circuit and components.
  1. Divide and conquer to defective component.
  2. Use schematic diagrams.
  3. Measure voltage and resistance.
  4. Test component parts.
- E. **Test** for proper operation after repair.
  1. Make sure the system works properly.
  2. Cook out to confirm repair.
  3. Prepare unit for return to customer.

II. Locating to stage or smaller section

A. Divide the larger area down to an individual stage, or in some cases a group of two or three stages.

1. The larger area is determined by symptom diagnosis.

2. Test equipment can be used at this step.

3. Limit VOM use to checking DC supply voltages.

B. There are two basic methods of locating the defective stage.

1. Signal trace **(HO 1.1)**

2. Signal inject **(HO 1.2)**

C. A combination of tracing and injection can be used.

III. Signal-trace method **(HO 1.1)**

A. Follow signal from input toward output.

1. Follow the signal until it distorts or quits.

2. Where the signal ends is the defective stage. The defective stage is between the point where the signal was last observed and the point where it quits.

B. Test equipment must have an output indicator.

1. Oscilloscope

CAUTION: Observe grounding safety rules when using the oscilloscope. An isolation transformer is required when using the oscilloscope.

a. CRT screen displays signal waveform.

b. The oscilloscope is most versatile as it will trace AF, RF, sine and pulse waveforms.

2. Signal tracer

a. A loudspeaker or headphone indicates output.

b. An audio amplifier can be used.

c. Signal tracers are most useful for audio frequencies and tracing RF when used with a detector probe.

d. Signal tracers are easily constructed.

3. VOM

a. Meter scale or digital display which indicates voltage

b. Most useful for some audio tracing and AC power waveform in power supplies

4. Logic probe

    a. The LED indicates logic level and pulse activity.

    b. Logic probes are most useful for digital applications.

    c. The VOM can substitute for a logic probe.

        (1) 0-1V DC for a logic 0

        (2) 4-5V DC for a logic 1

C. Tracing starts where the signal enters the section.

1. Use the tracer to see if the signal has passed through an amplifier.

    a. Trace at input of an amplifier stage.

        (1) Base of a common-emitter amplifier

        (2) Emitter of common-base amplifier

        (3) Base of common-collector amplifier

    b. If signal is present at an input, go to the input of another stage.

    c. Follow signal flow as shown on the block diagram. **(HO 1.1)**

2. The tracer "pulls" the signal out of the unit under test. Tracer output substitutes for the unit's normal output.

D. Divide and conquer.

1. Make as few checks as needed to locate the defective stage.

2. Never try to troubleshoot the whole system.

3. Divide the section into halves.

    a. Test for a signal at the input of every second or third stage. (This is faster than testing each individual stage.)

    b. If the signal is present at that input, move down two or three more stages. Test at that stage's input.

    c. If a signal is not present at that stage, move back one stage and test at the input.

    d. If signal is not present at that stage, move back one stage and test at the input.

E. Tracing ends where the signal is lost.

1. After the last stage, input where the signal was present.

2. Before the stage, input where signal is missing.

3. Sometimes the exact stage cannot be pinpointed.

a. Define it as closely as possible. Where was the signal definitely lost and where it was definitely present?

b. The defective stage is between those two points.

F. Start where the signal enters the section.

G. Follow the signal path until signal flow is interrupted.

IV. Signal-injection method **(HO 1.2)**

A. Inject a signal near the output and work back toward the input.

1. If signal appears at the output, that stage is working and all stages between the injection point and output are working.

2. Move the injection point back to the stage's input and closer to system input.

B. Test equipment must produce a waveform or signal.

1. Audio oscillator

a. Generates audio frequencies

b. Audio heard if signal comes out of speaker

(1) The stages between the generator and speaker are tested.

(2) Stages must be working or the signal will not pass through them.

c. Most useful for PA, music instrument and stereo amplifiers, as well as the audio sections of radio or television receivers.

2. Function generator

a. Generates audio frequencies and higher

b. Audio heard if signal comes out of speaker

(1) The stages between the generator and speaker are tested.

(2) Stages must be working or the signal will not pass through them.

c. Most useful for audio, video and pulse amplifiers

3. RF oscillator

a. Inject radio frequencies (modulated or unmodulated)

b. Most useful for AM and FM radio

4. Video pattern generator

a. Generate video and/or color video

b. Most useful for television receivers and computer CRT monitors

5. Finger

   a. A hum from the power lines is caused by the human body.

   b. Finger-testing can be used on video amplifiers, though it may cause screen disturbance.

   c. Finger-testing is most useful on a PA audio generator, music instrument or stereo amplifiers and audio sections of radio and television receivers.

   CAUTION: Do not touch any test point or equipment of more than 12 volts!

   d. Touch the fingertip to the test point. Holding a small screwdriver, touch the screwdriver tip to the test point.

C. Injection starts near the system's output.

1. Use injection to see if the signal will pass through an amplifier.

   a. Inject at the input of an amplifier stage.

      (1) Base of a common-emitter amplifier

      (2) Emitter of common-base amplifier

      (3) Base of common-collector amplifier

   b. If signal passes through the amplifier, move back to the previous stage's input.

   c. Inject backwards from the signal flow as shown on the block diagram. **(HO 1.2)**

2. The generator injects the signal into the unit under test. Generator output substitutes for the unit's normal signal input.

D. Divide and conquer.

1. Make as few checks as needed to locate the defective stage.

2. Never try to troubleshoot the whole system.

3. Divide section into halves.

   a. Inject signal at the input of every second or third stage. (This is faster than injecting at each individual stage.)

   b. Volume control of audio amplifier is a key test point since it's easy to locate. Touch a finger to the volume control; listen for speaker hum.

   c. If signal passes through at that input, move back two or three more stages and inject at stage input again.

   d. If signal does <u>not</u> pass through that stage, move down one stage and inject at that stage input.

   e. If signal does not pass through <u>that</u> stage, move down one stage and inject at that stage input.

E. Injection ends where the signal fails to pass through the amp.

1. Before the last stage input where signal was present

2. After the stage input where signal is missing

3. Exact stage sometimes not pinpointed

a. Define as closely as possible. Where was the signal definitely lost and where was it definitely present?

b. The defective stage is between those two points.

F. Start where the signal outputs from the section.

G. Follow the signal path backwards until signal flow is interrupted.

H. Combine injection and tracing.

1. Inject a signal at an early stage in the block diagram.

2. Trace the signal as far as possible.

V. Developing a method or style of troubleshooting

A. Understand what you are doing.

B. Use available test equipment.

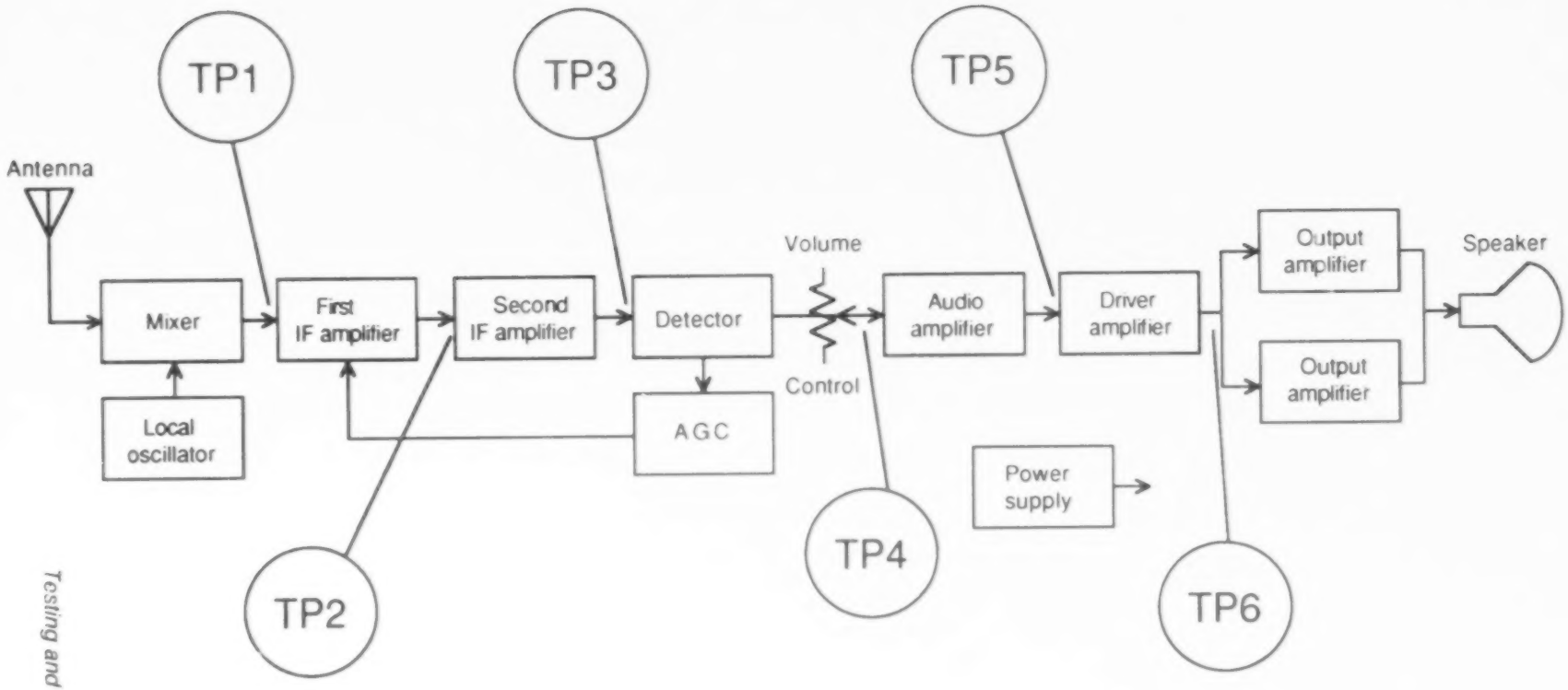
C. Use finger voltage when possible.

D. Practice your method on working equipment first.

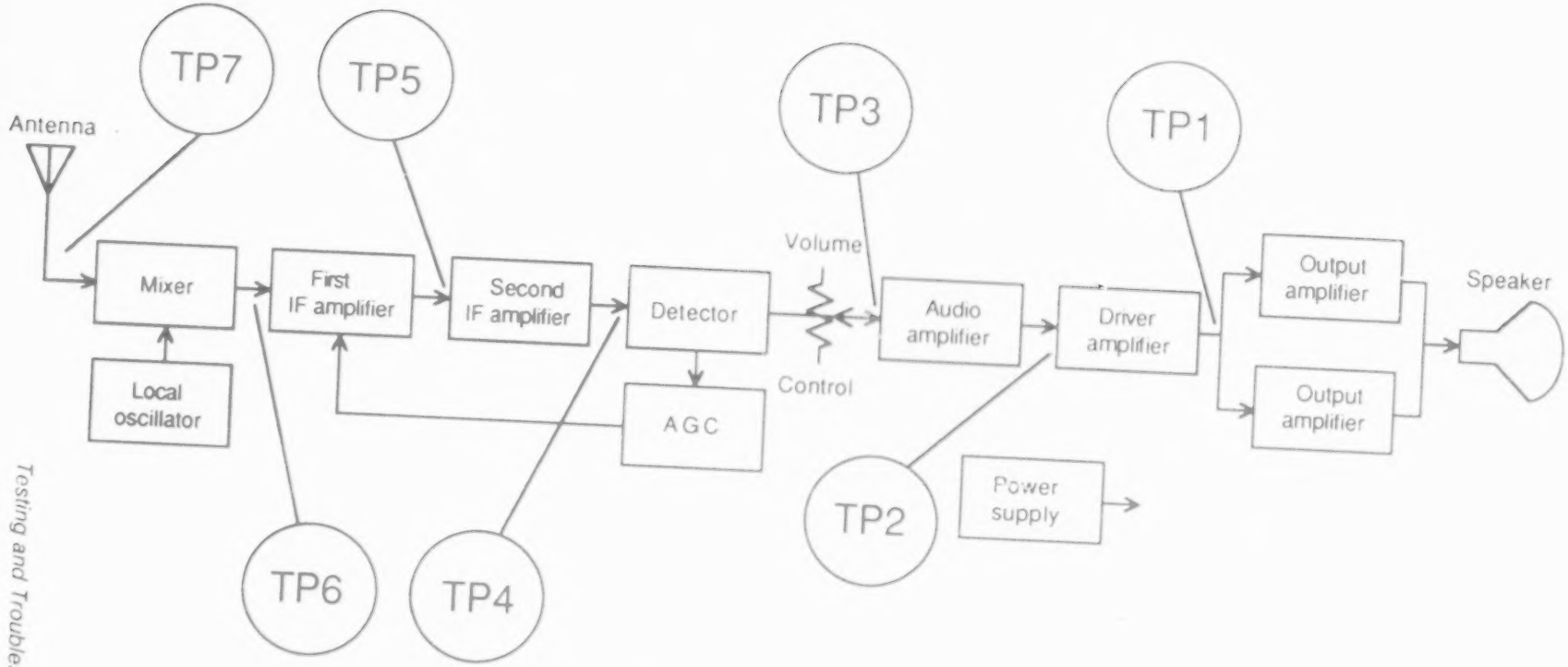
E. Narrow the search to a defective component.

1. Injection or tracing is not intended to find defective component part. Inject or trace to locate the defective stage.

2. Locate to the defective stage. Start with the whole system. Divide and conquer to the section, then to the stage. Troubleshoot in an organized manner.



SIGNAL TRACE



SIGNAL INJECT

TROUBLESHOOTING CHART

IDENTIFY

problem area, section or board by symptom diagnosis.

1. Start with whole system.
2. Divide and conquer to section.
3. Use block diagrams and troubleshooting flowcharts.
4. Use test equipment and voltage tests minimally.

LOCATE

problem area to a stage or smaller section.

1. Divide and conquer to stage.
2. Use block diagrams.
3. Use schematic diagrams.
4. Signal trace or inject.

ISOLATE

problem area to the defective unit, circuit and components.

1. Divide and conquer to defective component.
2. Use schematic diagrams.
3. Measure voltage and resistance.
4. Test component parts.

TEST

for operation after repair.

1. Make sure the system works properly.
2. Cook out the system to confirm repair.

PRACTICE TROUBLESHOOTING TO DEFECTIVE STAGE

NOTE: Ask the instructor for equipment to practice signal trace and signal inject procedure.

Equipment: _____

Model #: _____ Serial #: _____

Procedure:		Evaluation 3	2	1	N
1.	Analyze defective system.	__	__	__	__
2.	Observe symptoms.	__	__	__	__
3.	Analyze observations.	__	__	__	__
4.	Use the major troubleshooting assumption.	__	__	__	__
5.	Perform inspection.	__	__	__	__
6.	Use troubleshooting aids.	__	__	__	__
7.	Use divide-and-conquer technique.	__	__	__	__
8.	Identify the problem area by symptom.	__	__	__	__
9.	Make proper use of the VOM.	__	__	__	__
10.	Diagnose by signal trace to the defective stage.	__	__	__	__
11.	Make proper use of the oscilloscope.	__	__	__	__
12.	Diagnose by signal injection to the defective stage.	__	__	__	__
13.	Make proper use of the signal generator.	__	__	__	__
14.	Locate defective stage.	__	__	__	__
15.	Use safe troubleshooting procedure.	__	__	__	__
16.	Clean up work area.	__	__	__	__
17.	How long did it take to perform this procedure? Hours: _____ Minutes: _____	__	__	__	__
Average of above evaluations*		__	__	__	__

*This average is the student's partial evaluation for competencies N2-3 and H1-3.

MODULE: TESTING AND TROUBLESHOOTING

UNIT III: COMPONENT-LEVEL TROUBLESHOOTING

LESSON 2: ISOLATE DEFECTIVE UNIT

I. Isolating defective circuit and components

NOTE: Schematic diagrams are useful at this stage of troubleshooting.

A. Test the defective stage.

1. Voltmeter tests

2. Ohmmeter tests

3. Component analyzer

B. Do voltmeter tests first, then ohmmeter tests. Test DC operating voltages on transistor or I.C.

1. Voltages should be within about 10% of schematic value.

2. Test supply voltage (V_{cc}) for the stage.

C. Test collector voltage of common-emitter voltage amplifier.

1. Collector voltage is normally 50%-60% of V_{cc}.

2. If collector voltage is too low, the transistor may be conducting too much.

a. Feel transistor for excessive heat or improper bias.

b. Also check for short or low resistance to ground; increased load resistance value; improper bias; and shorted coupling capacitor to previous stage, bypass capacitor to ground or transistor.

3. If collector voltage is too high, the transistor may not be turned fully on.

a. Check for improper bias.

b. Also check for the emitter resistor opening up or an open transistor.

4. Integrated circuits are difficult to test.

a. I.C.s are circuits, not parts.

b. Test parts connected to the I.C.

c. When parts are proven to be OK, try a new I.C.

D. Test component parts with an ohmmeter.

1. Capacitors

a. Electrolytic capacitors most trouble-prone

(1) Shorts most common

(2) Leakage

(3) Open

(4) Value change usually not critical

b. Other capacitor types

(1) Shorts most common

(2) Leakage

(3) Open

(4) Value change can be critical

c. Ohmmeter checks: shorts, leakage, open

d. Change of value

(1) Use capacitor.

(2) Try new capacitor.

e. Replacement capacitors

(1) Near required value

(2) Same or higher voltage rating

(3) Never a lower voltage rating

2. Resistors

a. Bad resistors usually burn completely open or increase in value.

b. Open resistors are often caused by a shorted capacitor or transistor.

c. If resistor is burned or open, always assume another part shorted. Find and replace the shorted part.

d. Resistors seldom short. Look for a shorted capacitor instead.

e. Replacement resistors should be of the same value and same or higher wattage.

3. Semiconductors

a. Shorted semiconductors can be caused by improper bias, excessive heat or voltage, reverse voltage polarity or static voltage (damages MOS types).

b. Open semiconductors are caused by old age. They short first, then burn open.

c. Use factory-original replacement semiconductors, if possible. Look up replacements in the cross-reference.

4. Fuses

   a. Normal appearing fuses that are open can "die from old age" and be open from momentary power surges.

   b. Black or smoky fuses died violently because another part is shorted. Find and replace the shorted part.

   c. If a new fuse blows, another part is shorted. Do not "feed fuses"; find and replace the shorted part.

E. Test component parts with component analyzer.

   1. Component analyzer can be one of three types.

      a. Stand-alone (all in one unit)

      b. Add-on unit to use with oscilloscope

      c. Built-in test on some oscilloscopes

   2. Test semiconductors with a component analyzer.

      a. Shorts give a straight, vertical line display.

      b. Opens give a straight, horizontal line display.

      c. A good PN junction displays a sharp break.

   3. Test capacitors with component analyzer.

      a. Shorts give a straight, vertical line display.

      b. Opens give a straight, horizontal line display.

      c. A good capacitor is shown by a circular or oval display. (The oval opens up more with larger capacitors.)

F. If a component part tests bad while in the circuit, remove the part from the circuit and test again.

   1. Another part can be in parallel.

   2. Outside the circuit, parallel resistance is lower.

   3. If part still tests bad, replace it.

   4. If part tests OK out of circuit, it is good. Replace it and continue testing.

II. Replacing defective parts

A. Use factory-original parts or replacement parts.

B. Review Module 4: Circuit Construction Techniques, if needed.

C. Test for proper operation.

1. Review Unit II, Lesson 2, if needed.
2. Find another job to work on.

ISOLATE DEFECTIVE UNIT, CIRCUIT AND COMPONENTS

NOTE: Ask the instructor for equipment to practice isolating to defective unit, circuit and component procedure.

Equipment: _____

Model #: _____ Serial #: _____

Procedure:		Evaluation 3	2	1	N
1.	Analyze defective system.				
2.	Observe symptoms.				
3.	Analyze observations.				
4.	Use the major troubleshooting assumption.				
5.	Perform inspection.				
6.	Use troubleshooting aids.				
7.	Use divide-and-conquer technique.				
8.	Identify the problem area by symptom.				
9.	Make proper use of the VOM.				
10.	Diagnose by signal trace to defective stage.				
11.	Make proper use of the oscilloscope.				
12.	Diagnose by signal injection to defective the stage.				
13.	Make proper use of the signal generator.				
14.	Locate defective stage.				
15.	Make proper use of a component analyzer.				
16.	Isolate defective component part.				
17.	Replace defective component part.				
18.	Use safe troubleshooting procedure.				
19.	Identify the defective board or module.				
20.	Replace defective board or module.				
21.	Test the repaired unit.				
22.	Clean and adjust repaired unit.				

23. Replace covers, screws and cables. _____

24. Make final test. _____

25. Cook out repaired unit. _____

26. Use safe troubleshooting procedure. _____

27. Clean up work area. _____

28. Fill out work order or job ticket. _____

29. How long did it take to perform this procedure? _____

Work Order
ACME ELECTRONIC REPAIR
999 Any Street
Anytown, USA 99999-9999

Customer Name		Business/Address
Telephone		
Description	Model #	Serial #
Work Done		Date
		CHARGES Parts
Parts Used		
		Labor
Labor		
		Subtotal
Customer's Approval		
		Tax
Technician		TOTAL
On Site	Shop	Service Contract

Hours: _____ Minutes: _____

Average of above evaluations* _____

*This average is the student's final evaluation for competencies N2-N5 and H1-3.